Evaluating Major Shifts in America's Energy Portfolio: Experiences with POLYSYS

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Modeling Aggressive Renewable Energy Goals Workshop

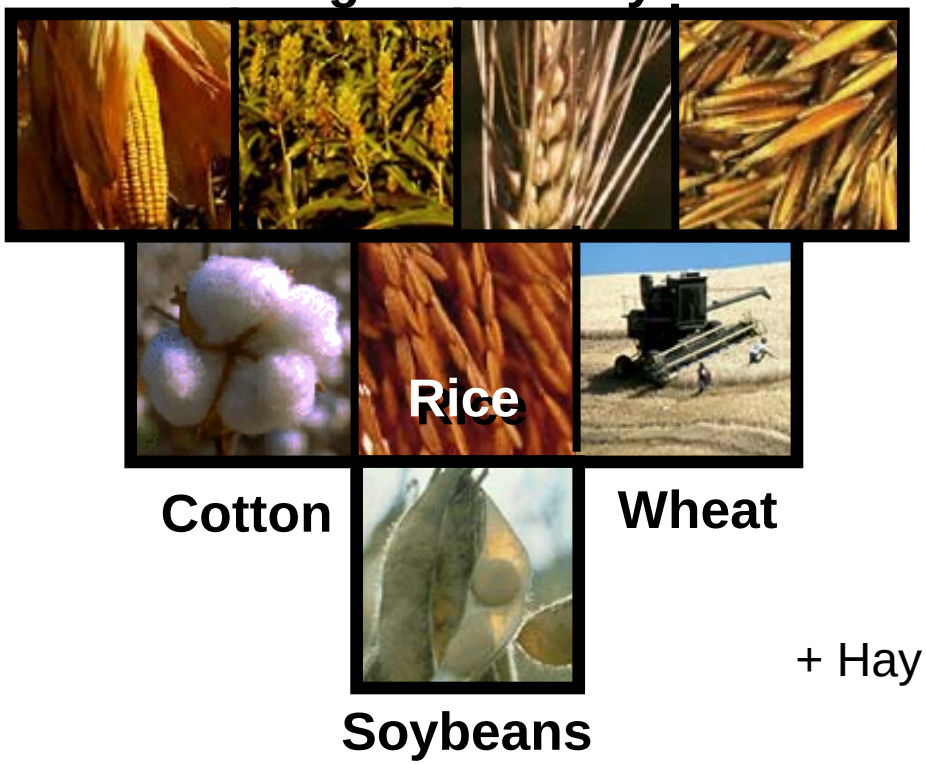
3-5 pm on June 27th
L'Enfant Plaza Hotel
Washington D.C.

The University of Tennessee
Agricultural Economics

Outline

- Brief introduction to POLYSYS
- Biofuels module design
- Assumptions required for POLYSYS analysis
- Sample results from POLYSYS
- Linkage to IMPLAN
- Economic impact results
- Conclusions and research needs

POLYSYS



+ Hay

ERS Livestock Model

POLYSYS

USDA Basline Corn	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
Planted acres (Mil)	80.90	81.60	80.50	81.00	82.00	84.00	84.50	85.00	85.00	85.00	84.50	84.50
Harvested acres	73.60	74.30	73.20	73.70	74.70	76.70	77.20	77.70	77.70	77.70	77.20	77.20
Yield/harvested acre	160.40	148.40	147.70	149.50	151.30	153.10	154.90	156.70	158.50	160.30	162.10	163.90
Exports	1,814	2,000	2,100	2,025	2,075	2,100	2,125	2,175	2,225	2,275	2,325	2,375
Farm price	2.06	1.80	2.00	2.20	2.45	2.55	2.60	2.60	2.60	2.55	2.60	2.60
Net returns (per ac)	197.05	135.40	124.44	125.37	164.79	182.16	192.15	194.51	197.01	191.54	202.15	204.73

Regional Acreage and Production

National Demands, Prices, Exports and Government Payments

(305 Linear Programming Models)

(Elasticities for price and export response)

Simulate Change

Demand, Exports, Land Availability, etc.

2004/05 2005/06 2006/07 2007/08 2008/09 2009/10 2010/11 2011/12 2012/13 2013/14 2014/15 2015/16

2016/17 2017/18 2018/19 2019/20 2020/21 2021/22 2022/23 2023/24 2024/25 2025/26 2026/27 2027/28

2028/29 2029/30

POLYSYS Regional Output

Annual acreage, production, government payments, income

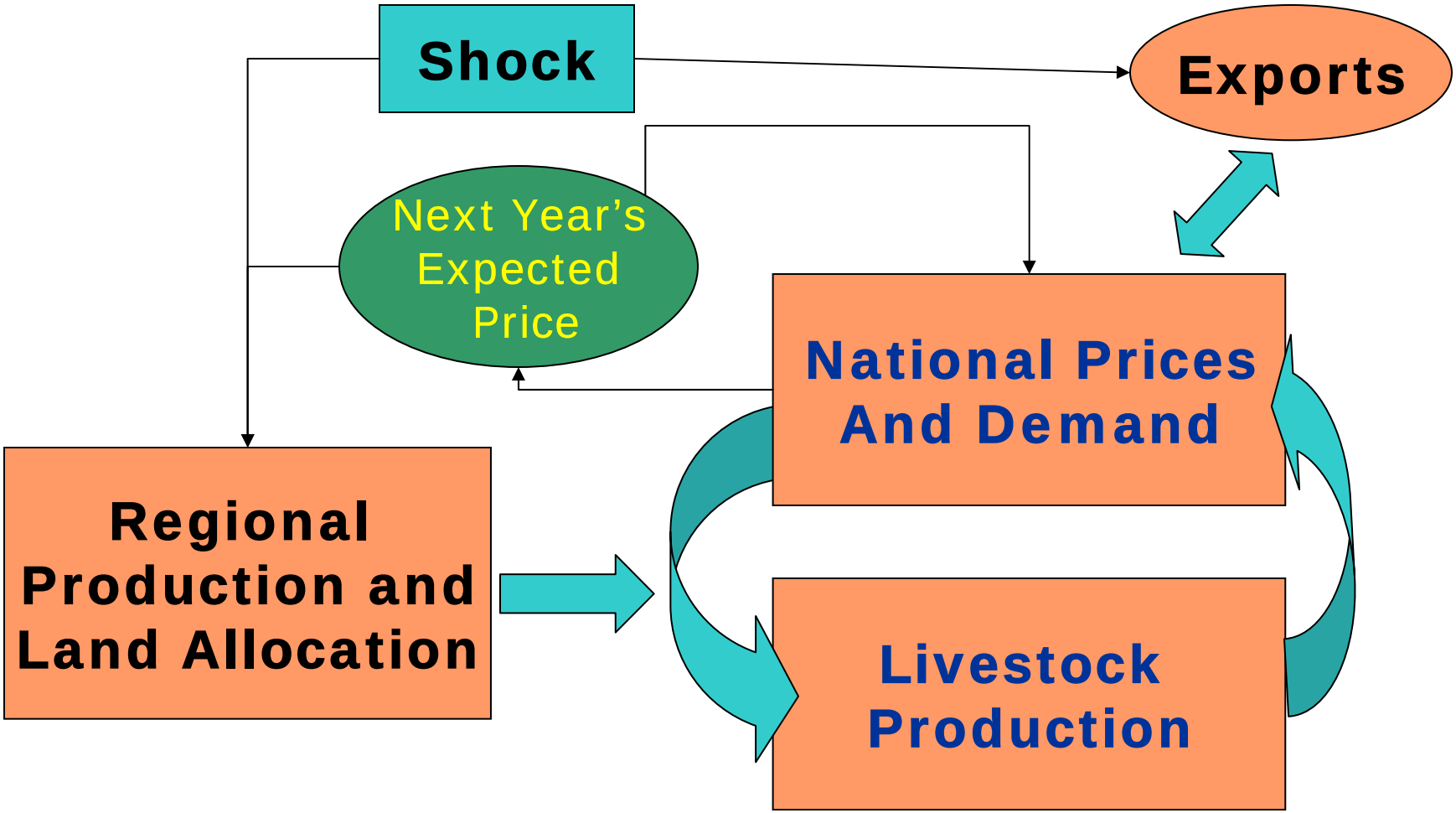
POLYSYS National Output

Annual Prices, production, government payments, exports, income.

POLYSYS

2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28
2028/29	2029/30										

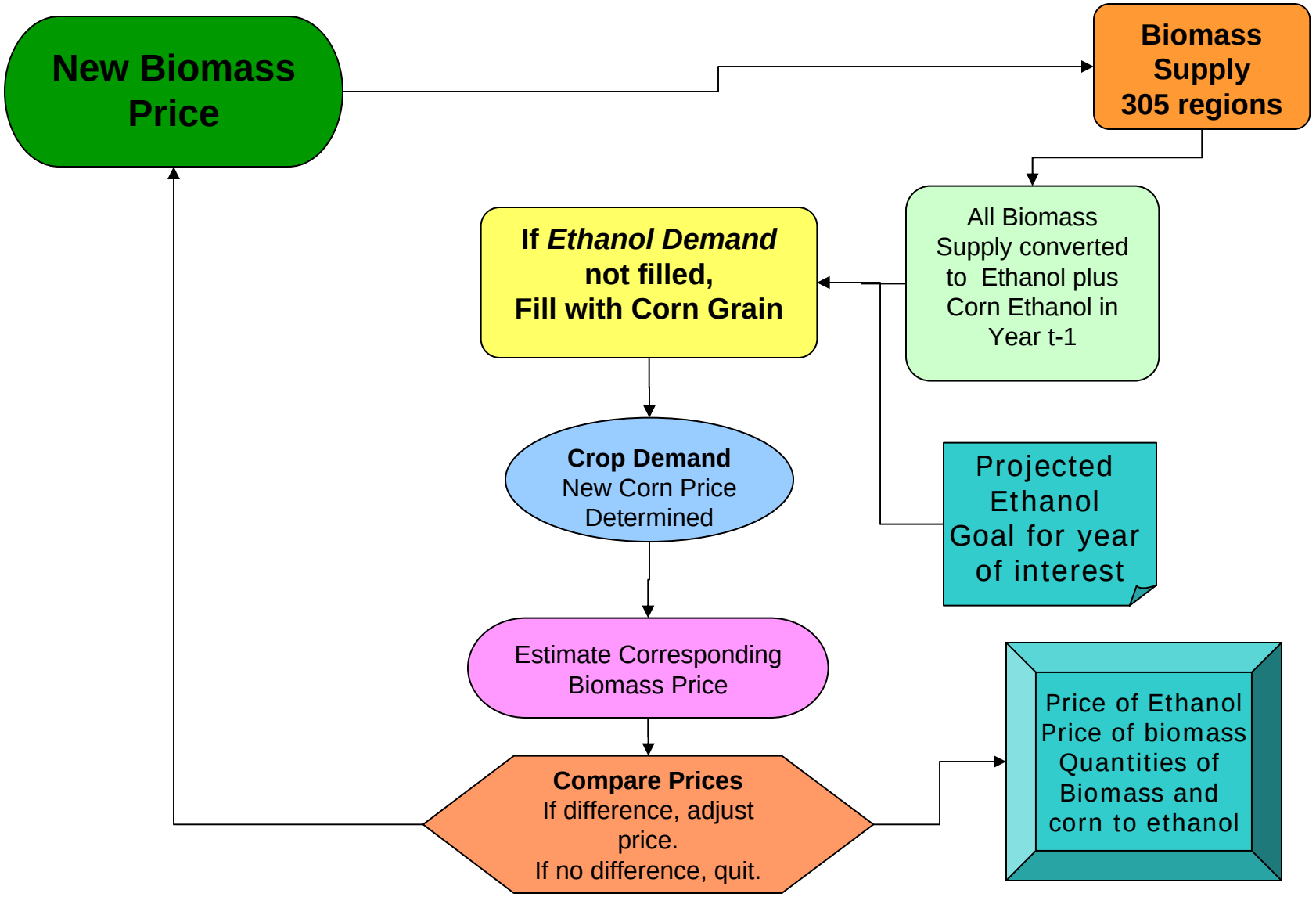
POLYSYS Simulation
Structure and Flow (Annual)



Additions for Biofuels Model

- Add Feedstocks
  - Energy Dedicated Crop – switchgrass.
  - Crop Residues – corn and wheat.
  - Wood Residues – forest thinnings, wood wastes and mill wastes.
  - Yellow grease and tallow
- Potential conversion of pasture.
- Corn grain and biomass ethanol compete.

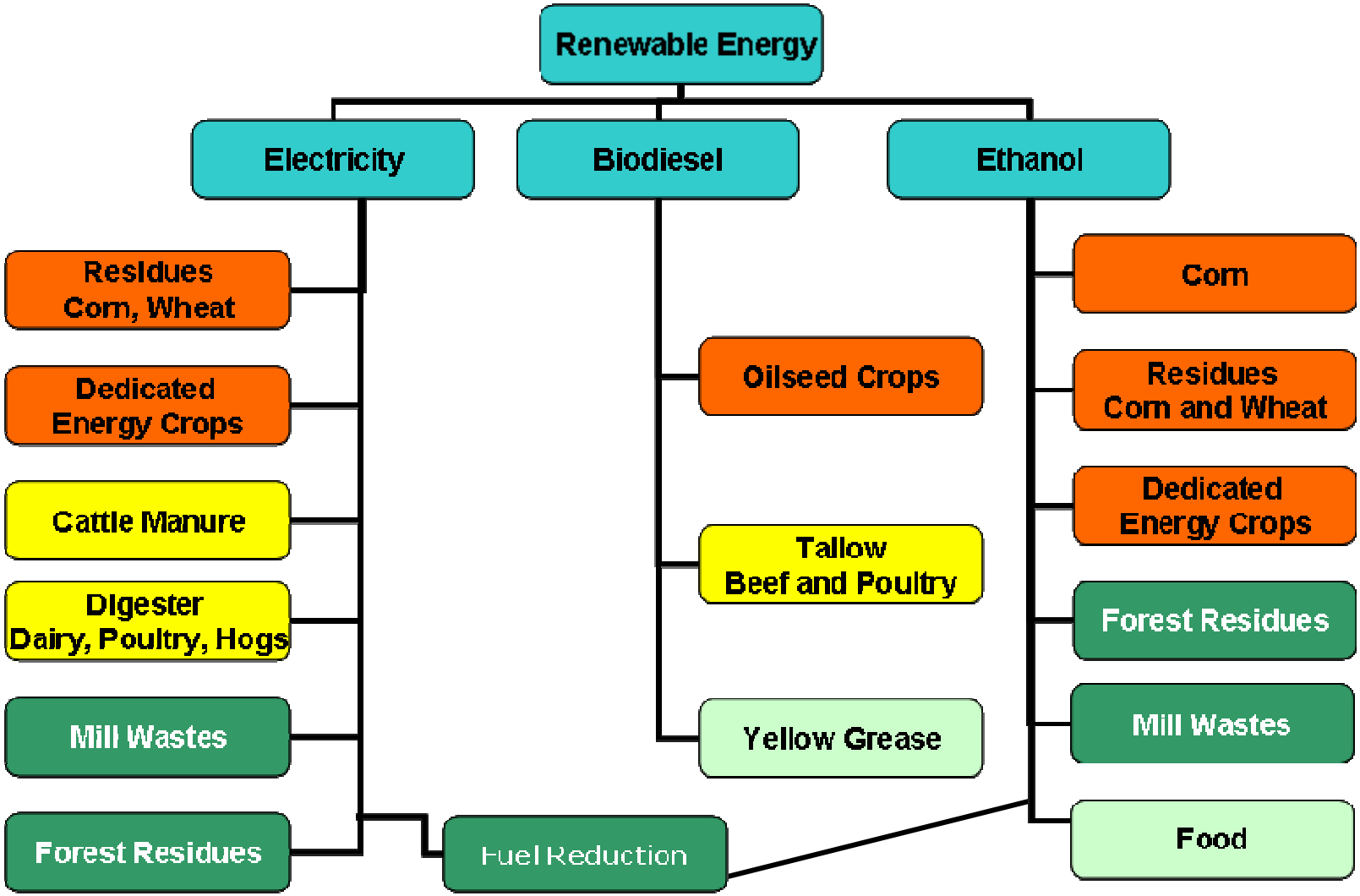
Finding Optimal Feedstock Mix



Projection of Energy Needs

Projection	Energy Demand (quads)
Department of Energy	126.99 in 2025 quads
RAND	117.7 in 2025 since replacement of coal reduces energy demand.
Current Level of Use	Roughly 101 quads in 2005

Renewable Energy Feedstocks From Agriculture



Renewables Not Modeled

Energy Source:	*2005[a] Quads*	*2025[b] Quads*
Geothermal	**0.30**	**2.08**
Solar Photovoltaic	**0.00**	**0.69**
Solar Thermal	**0.01**	**0.00**
Hydro	**2.80**	**3.10**
Wind	**0.11**	**4.04**
Total	**3.22**	**9.91**

[a] (DOE, 2006) [b] RAND analysis

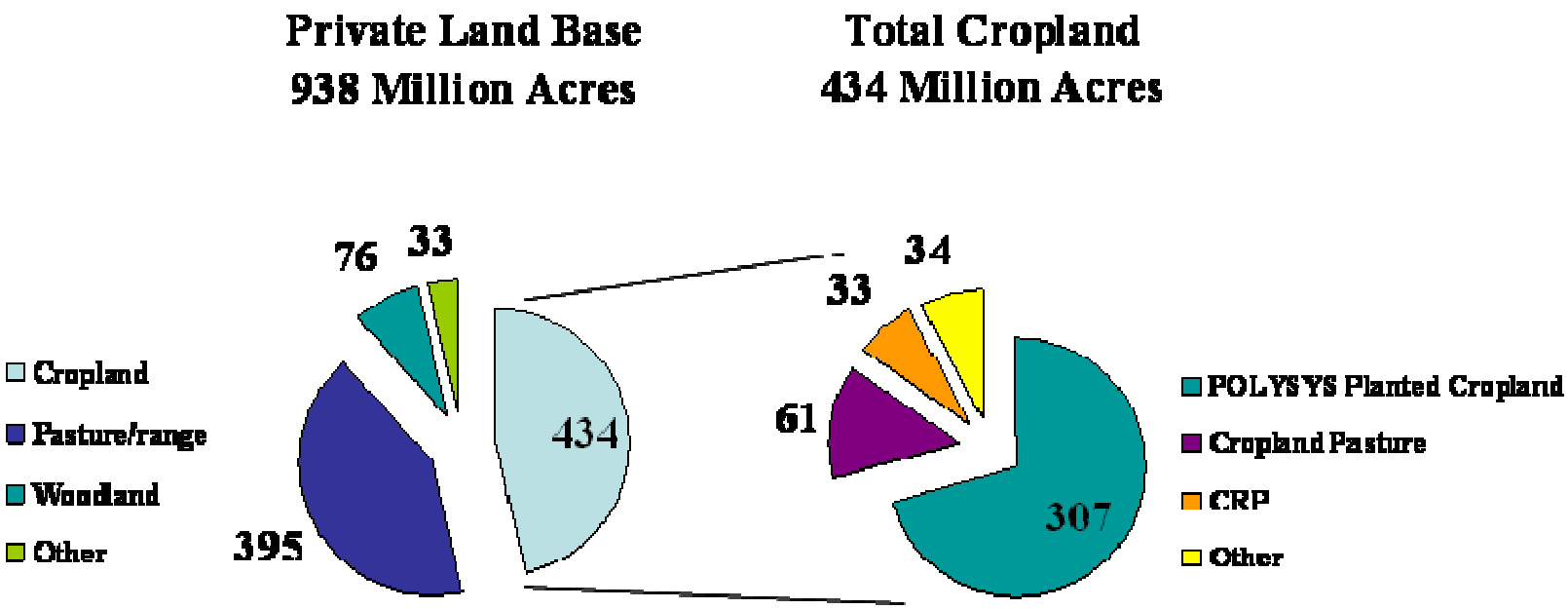
In addition, In 2005, there are 2.4 quads of biomass related energy currently used.

Projected Renewable Energy Production, 2025

Type of Energy	Units	Quantity	BTU's/unit	Quads
		Billion units		
Ethanol	Gallons	86.9	84,600	7.35
Biodiesel	Gallons	1.1	136,000	0.15
Electricity from Biomass	kWh	962	8,266	7.95
Wind	kWh	606.2	10280	6.23

[a] Also included in the analysis are the RAND projected levels for solar, hydro, and geothermal.

Land Use by Major Use Category, 2002.



Source: USDA, National Agricultural Statistical Service, 2004.

Assumptions for a Potential Outlook

- **Yield by 2025:**
  - **Crops: corn (195 bu/ac), soybeans (51 bu/ac), wheat (53.00 bu/ac), energy crop (6 to12 dt/acre).**
- **Management Practices:**
  - **Increase crop residues by shifting corn and wheat acreage to 50% no-till, 30% reduced till and 20% conventional till by 2025.**

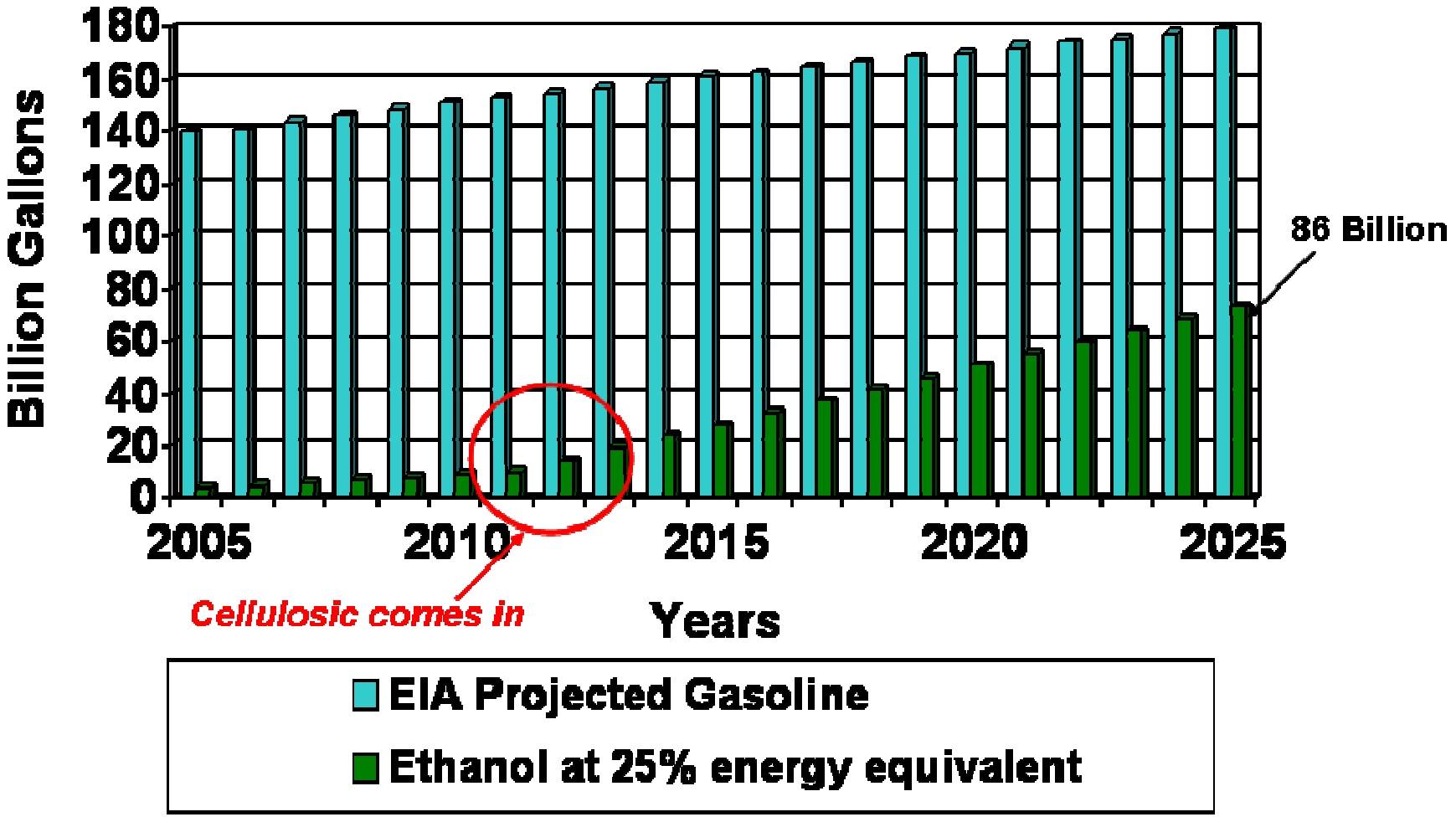
Rate of Growth Increase in Yields Assumed Beyond 2015

	USDAext	AE
Corn (bushels)	1.13%	1.69%
Sorghum (bushels)	0.76%	1.13%
Oats (bushels)	0.61%	0.91%
Barley (bushels)	0.88%	1.31%
Wheat (bushels)	0.88%	1.32%
Soybeans (bushels)	0.93%	1.39%
Cotton (pounds)	0.43%	0.64%
Rice (pounds)	0.79%	1.19%

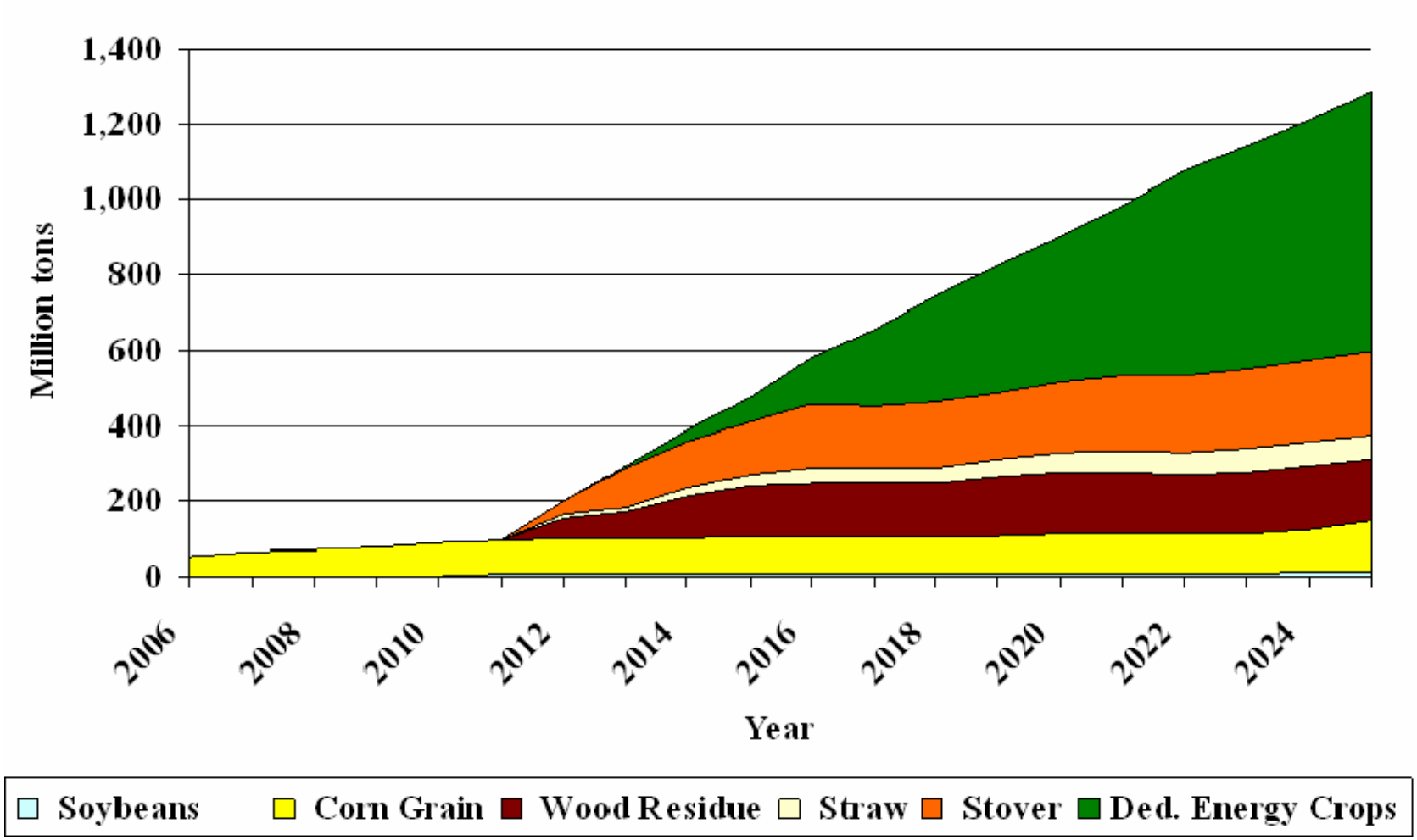
Assumptions for a Potential Outlook

- **Commodity Programs:**
  - **Remain as specified in 2006.**
- **Conversion Efficiency:**
  - **Improved cellulosic ethanol to 89 gallons/ton by 2025 and corn ethanol conversion to 3 gallons/bushel (97 gallons/ton) by 2015. Other means to produce ethanol from food wastes remained at the current conversion rate.**

Expansion Assumption

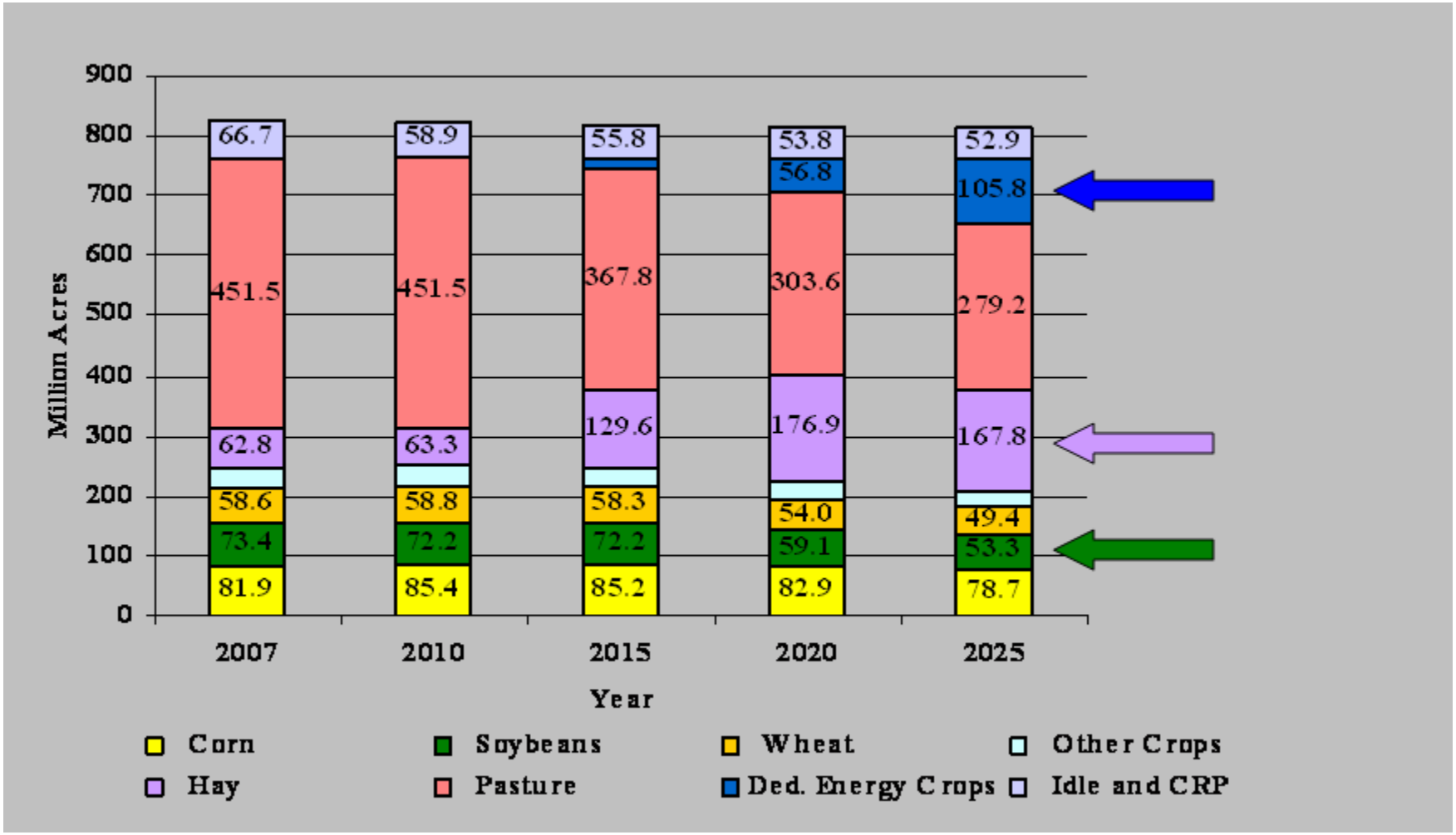


Feedstock for Energy: Converted to Energy



Land Use: 2007, 2010, 2015, 2020, and 2025

(million acres)

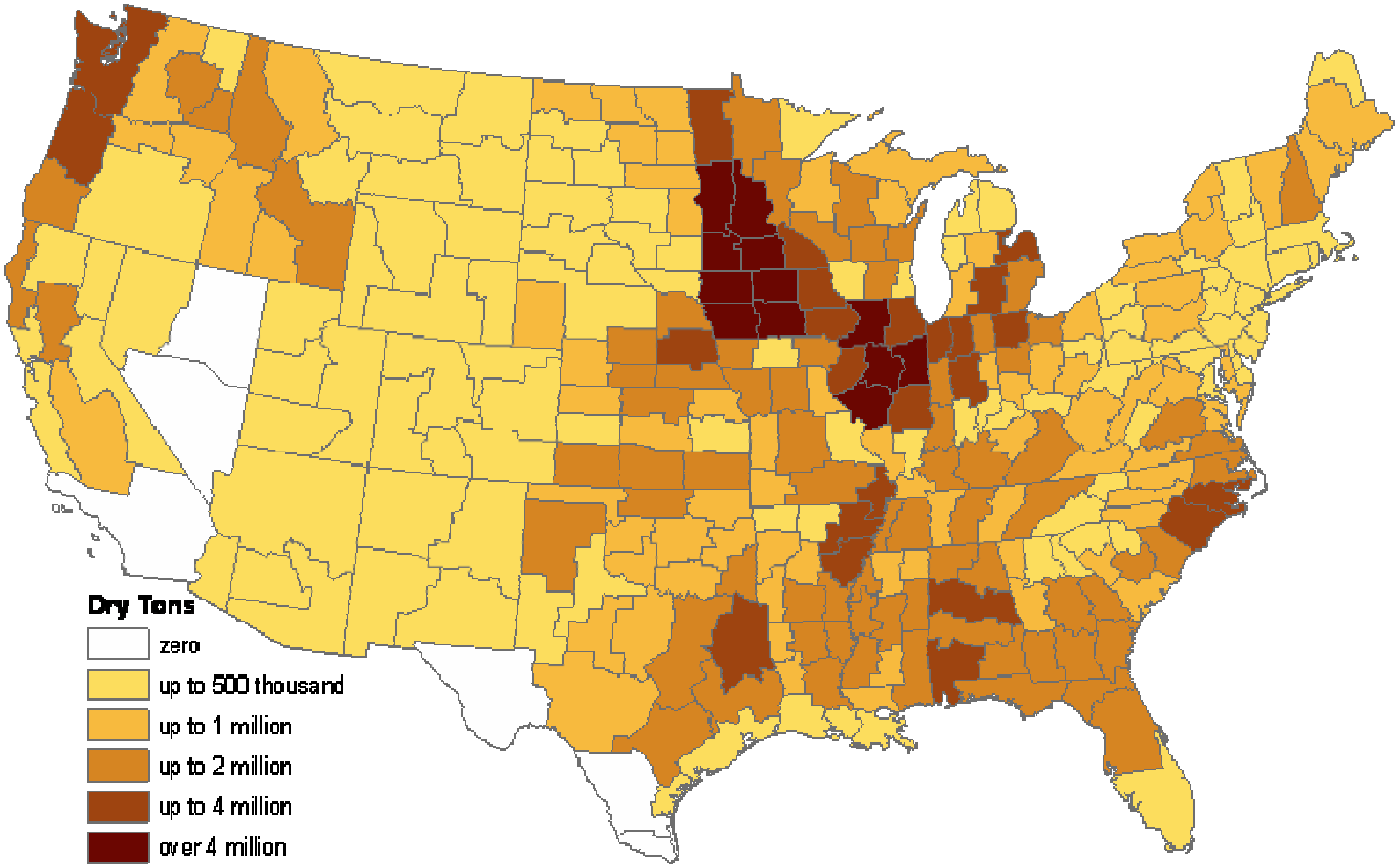


Estimated Change in Prices

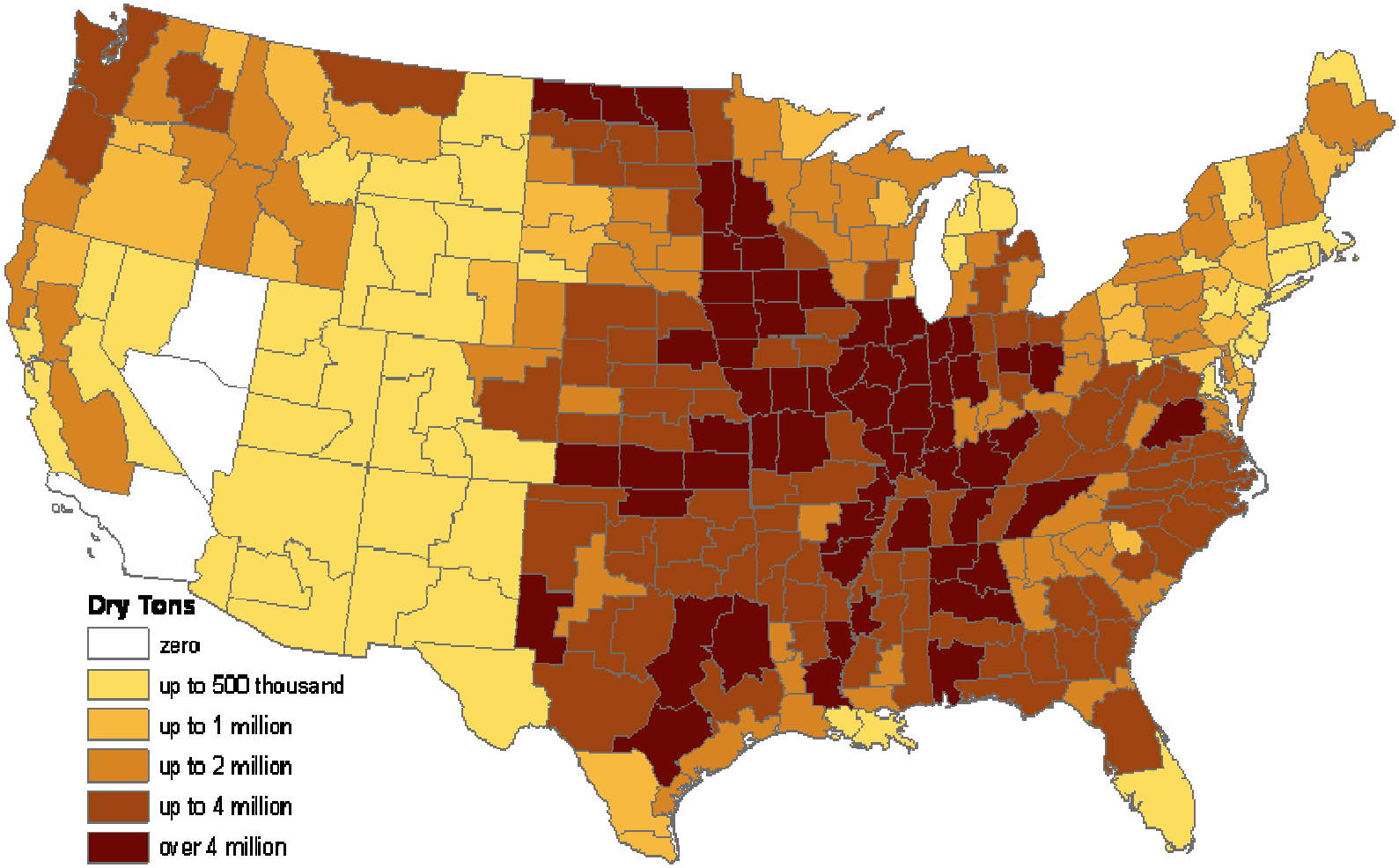
	$/bu from baseline			
Crop	**2010**	**2015**	**2020**	**2025**
Corn	**0.16**	**0.02**	**0.16**	**0.71**
Wheat	**-0.12**	**-0.23**	**0.33**	**0.48**
Soybeans	**0.09**	**0.16**	**1.69**	**2.04**
		$/dry ton		
Dedicated Energy Crops	**0**	**46.85**	**60.9**	**81.85**
		$/gallon		
Cost of Ethanol	**1.57**	**1.38**	**1.44**	**1.60**

Distribution of the Production of Cellulosic Materials, 2010

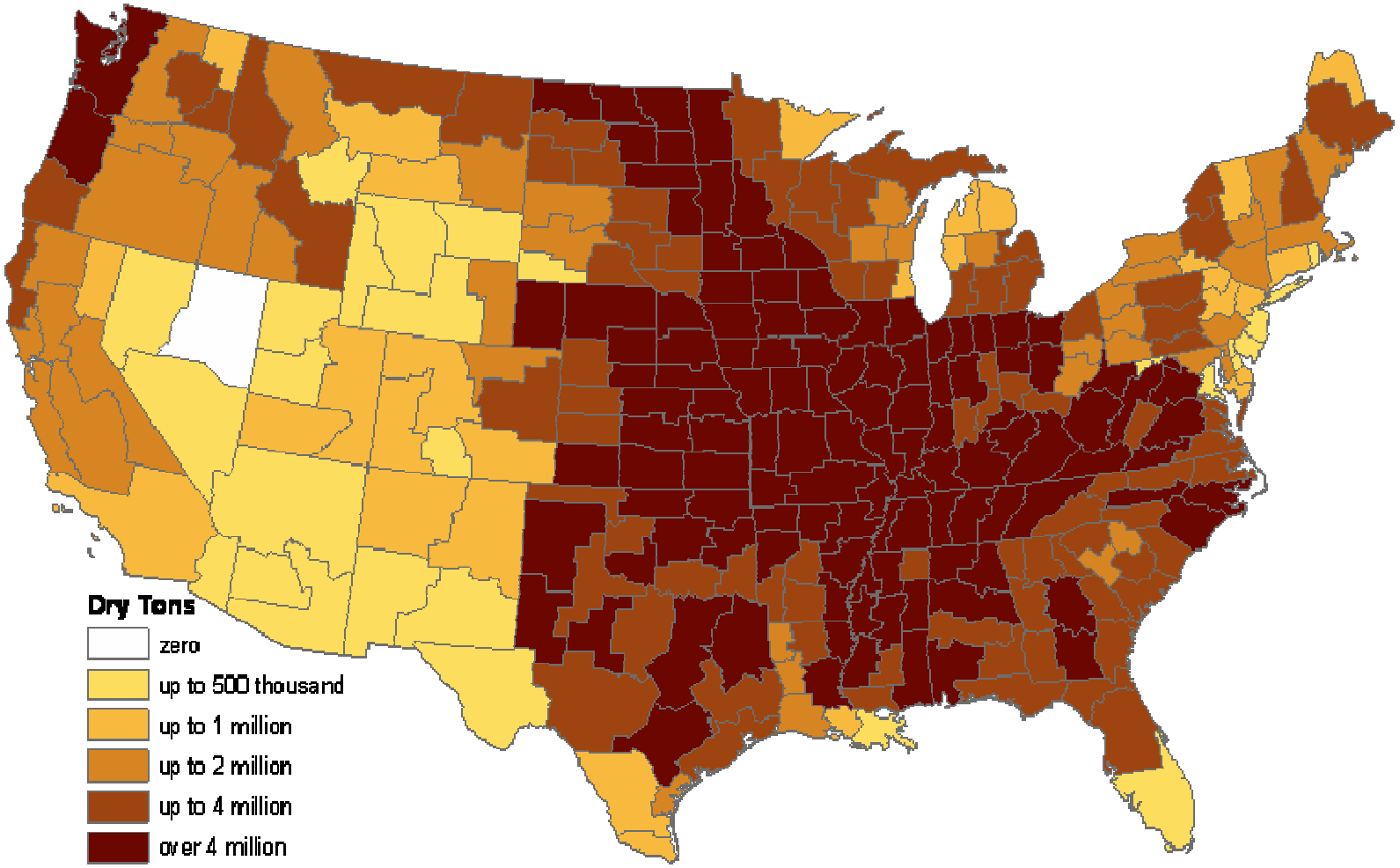
Distribution of the Production of Cellulosic Materials, 2015



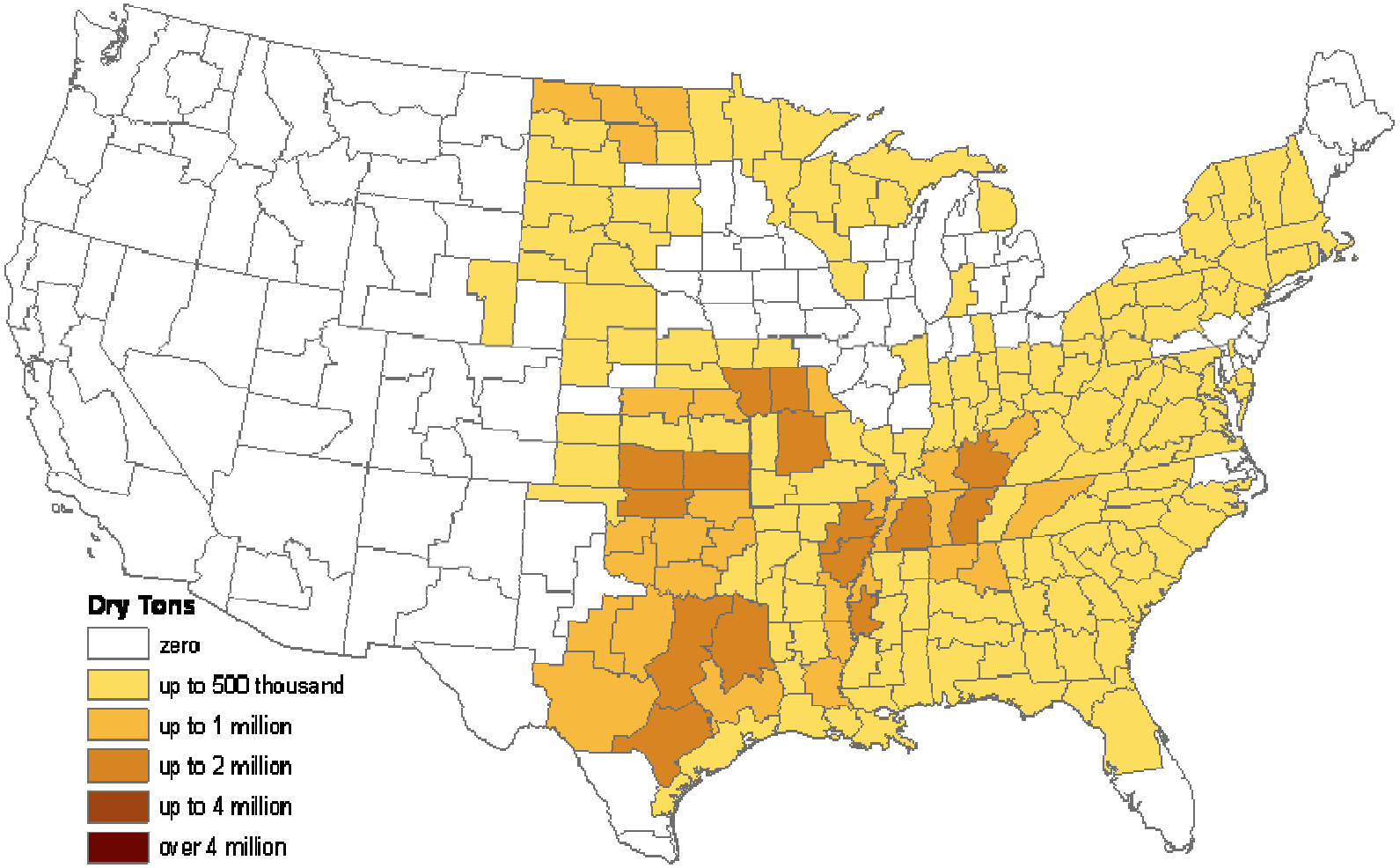
Distribution of the Production of Cellulosic Materials, 2020



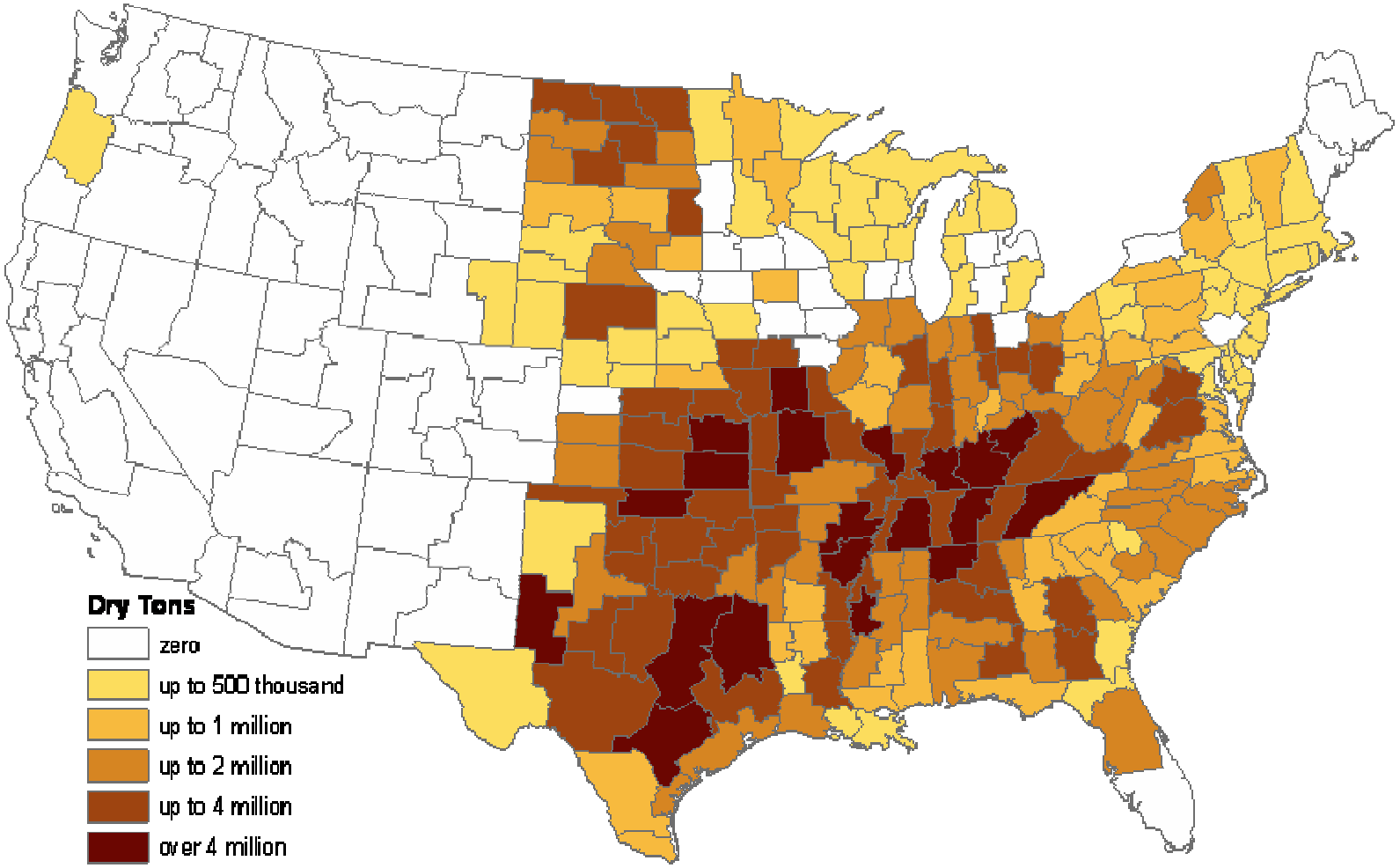
Distribution of the Production of Cellulosic Materials, 2025



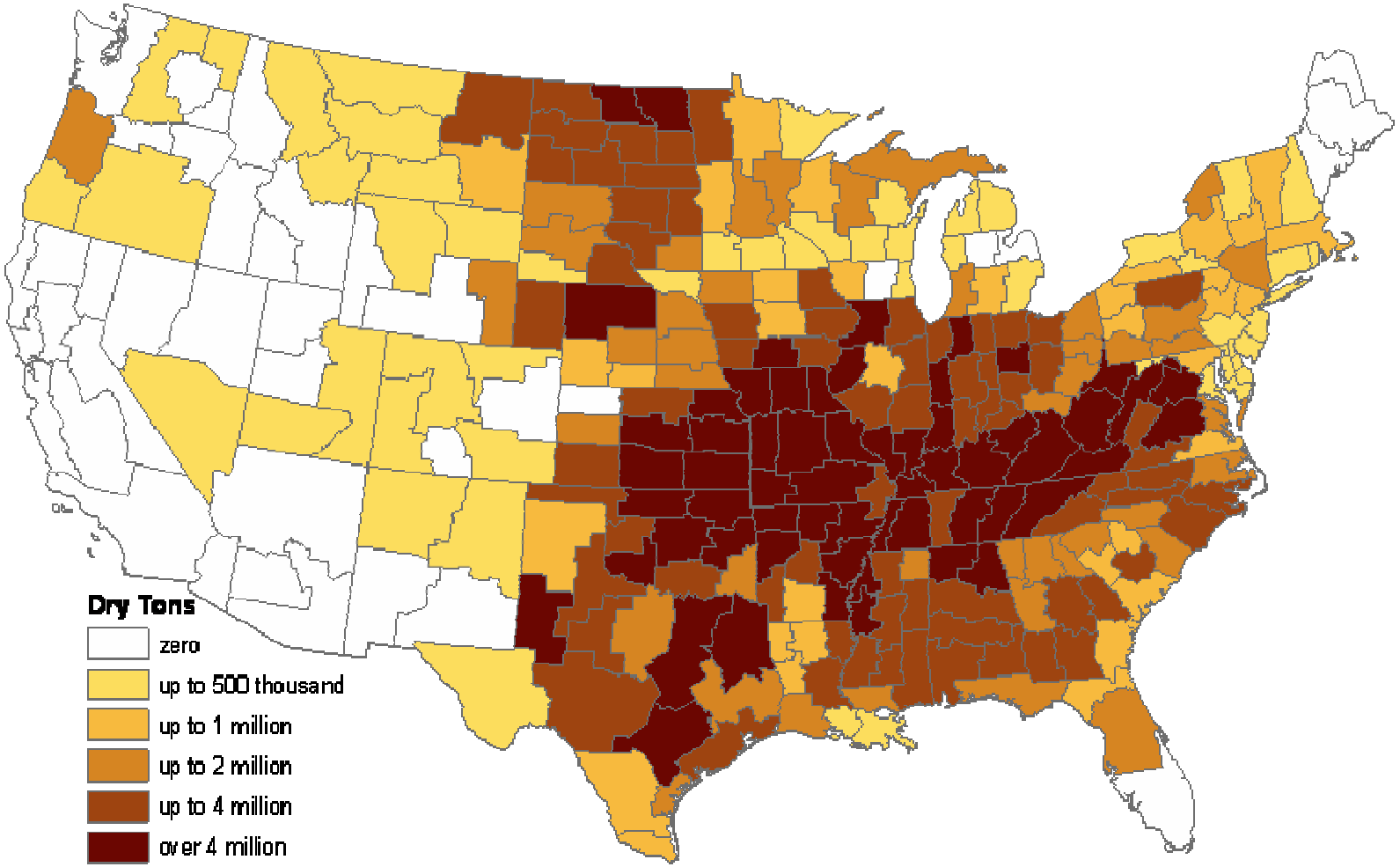
Distribution of the Production of Dedicated Energy Crop, 2015



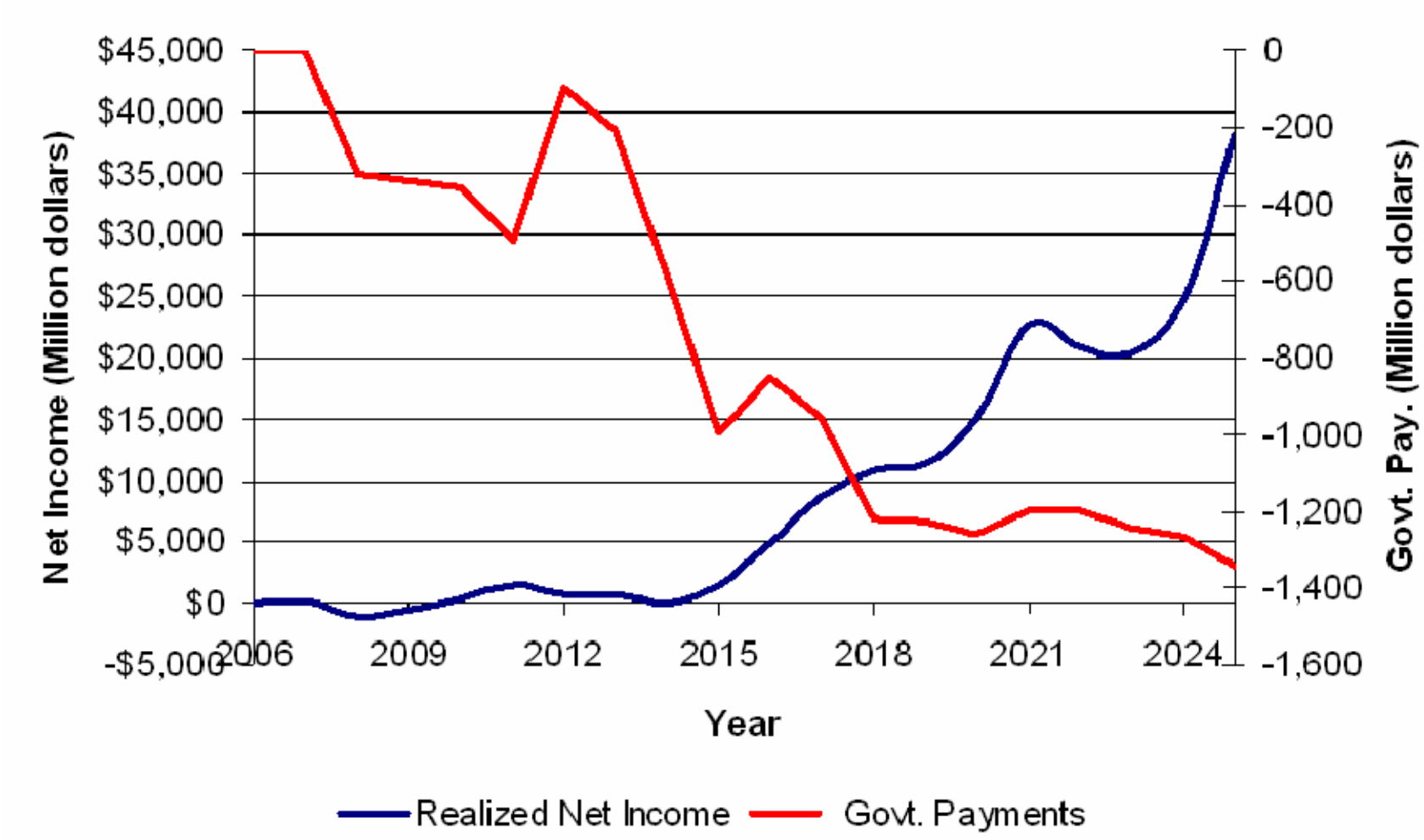
Distribution of the Production of Dedicated Energy Crop, 2020



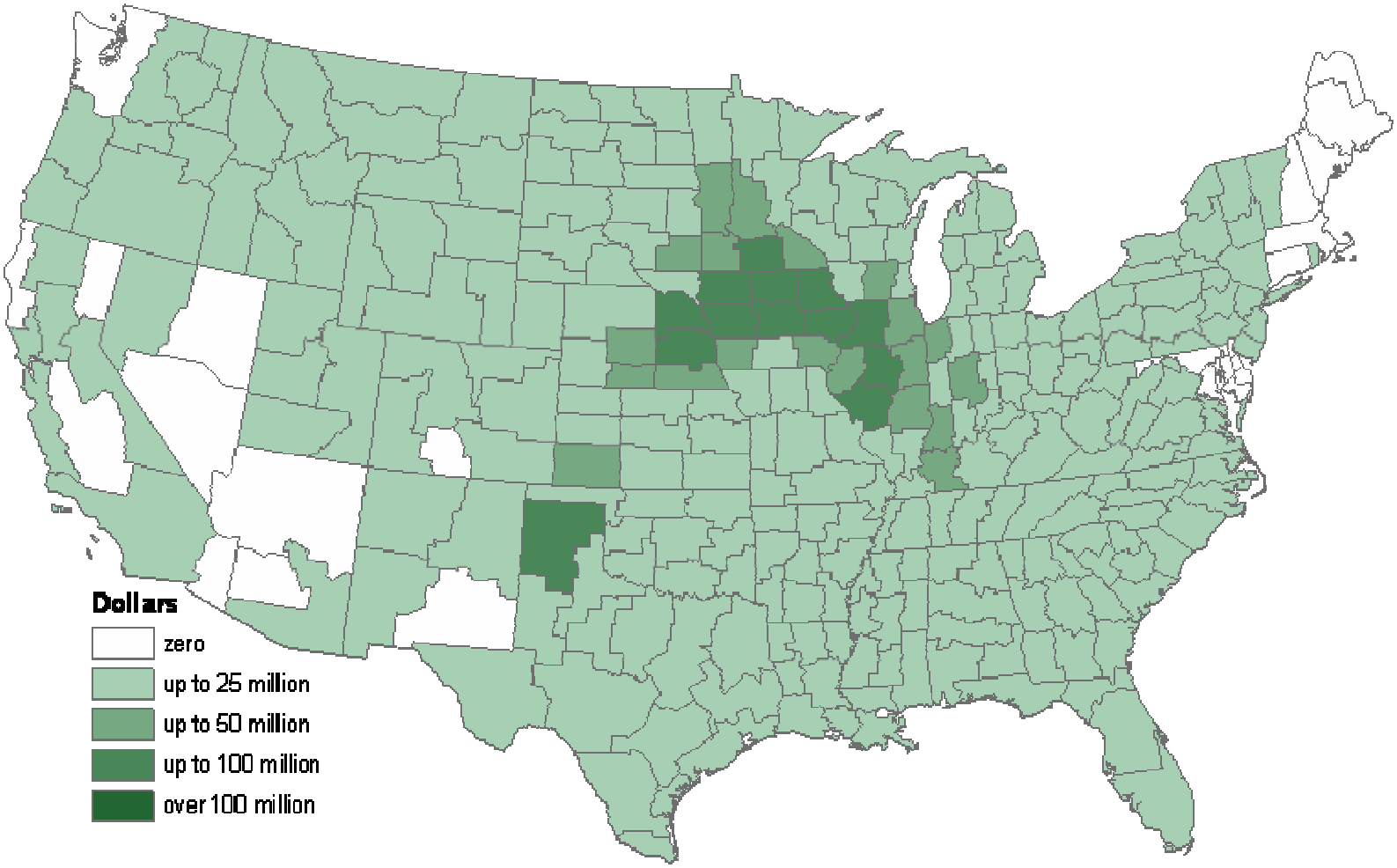
Distribution of the Production of Dedicated Energy Crop, 2025



Changes in Farm Income and Government Payments (million $)



Change in Net Returns -- 2010



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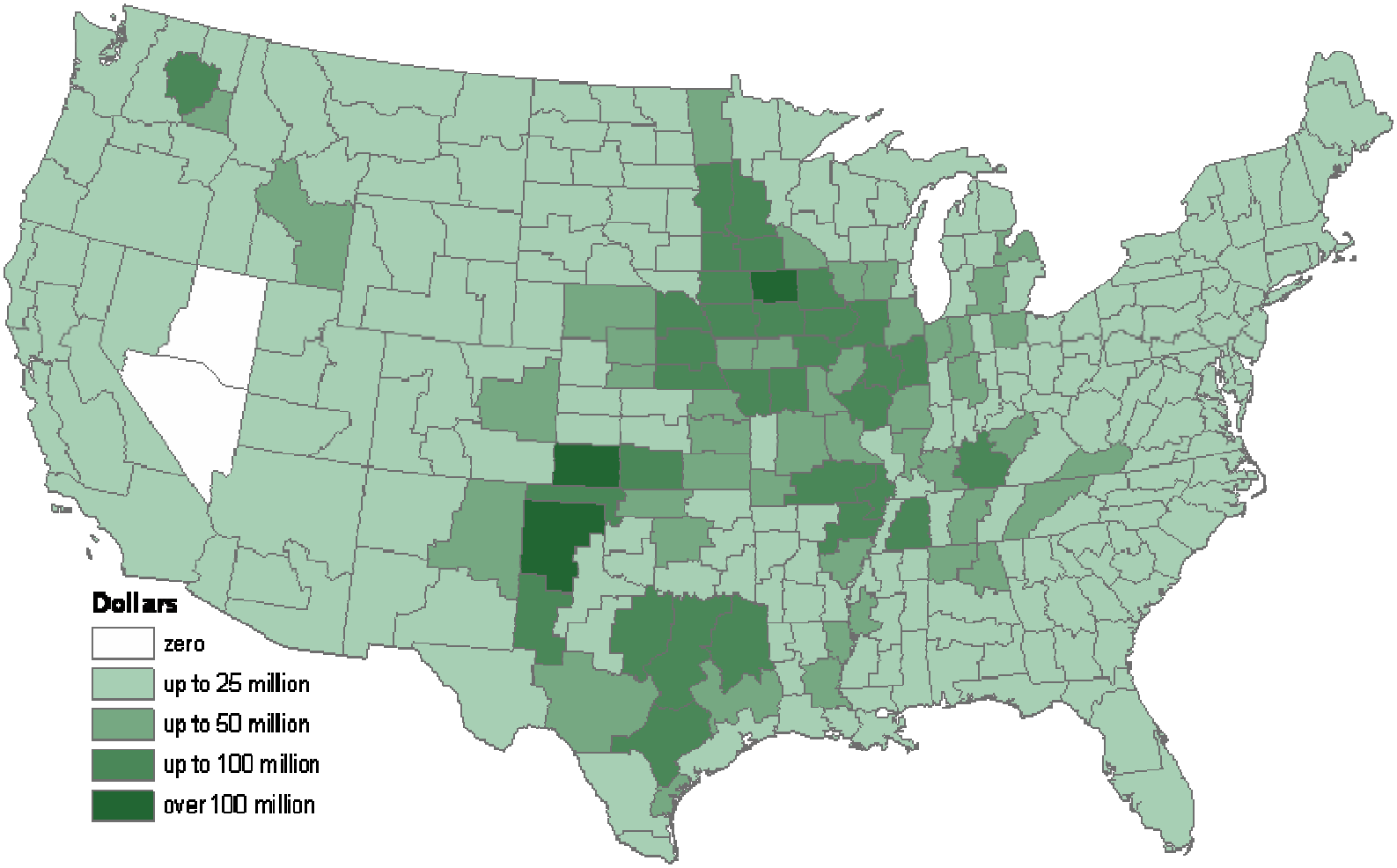

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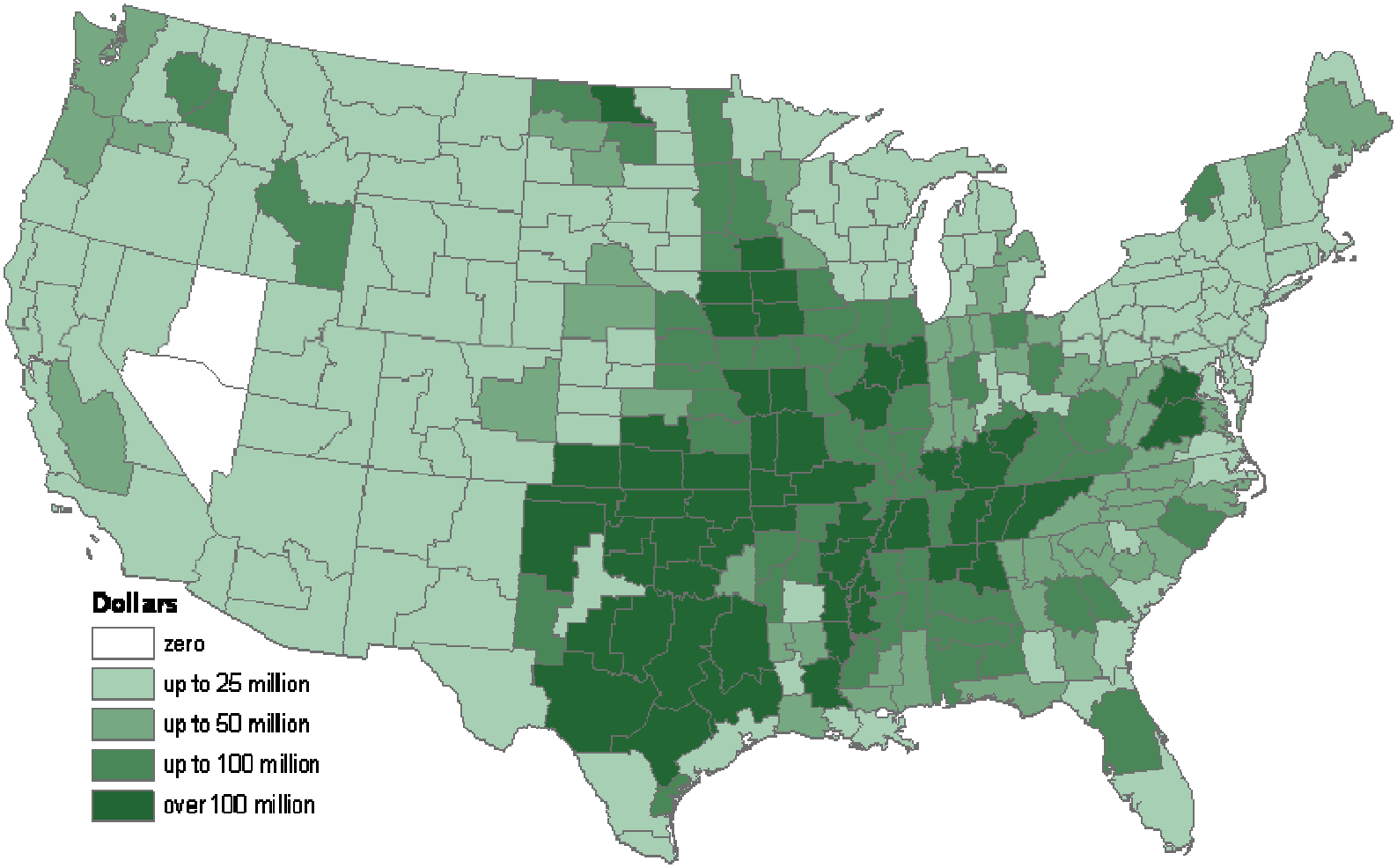
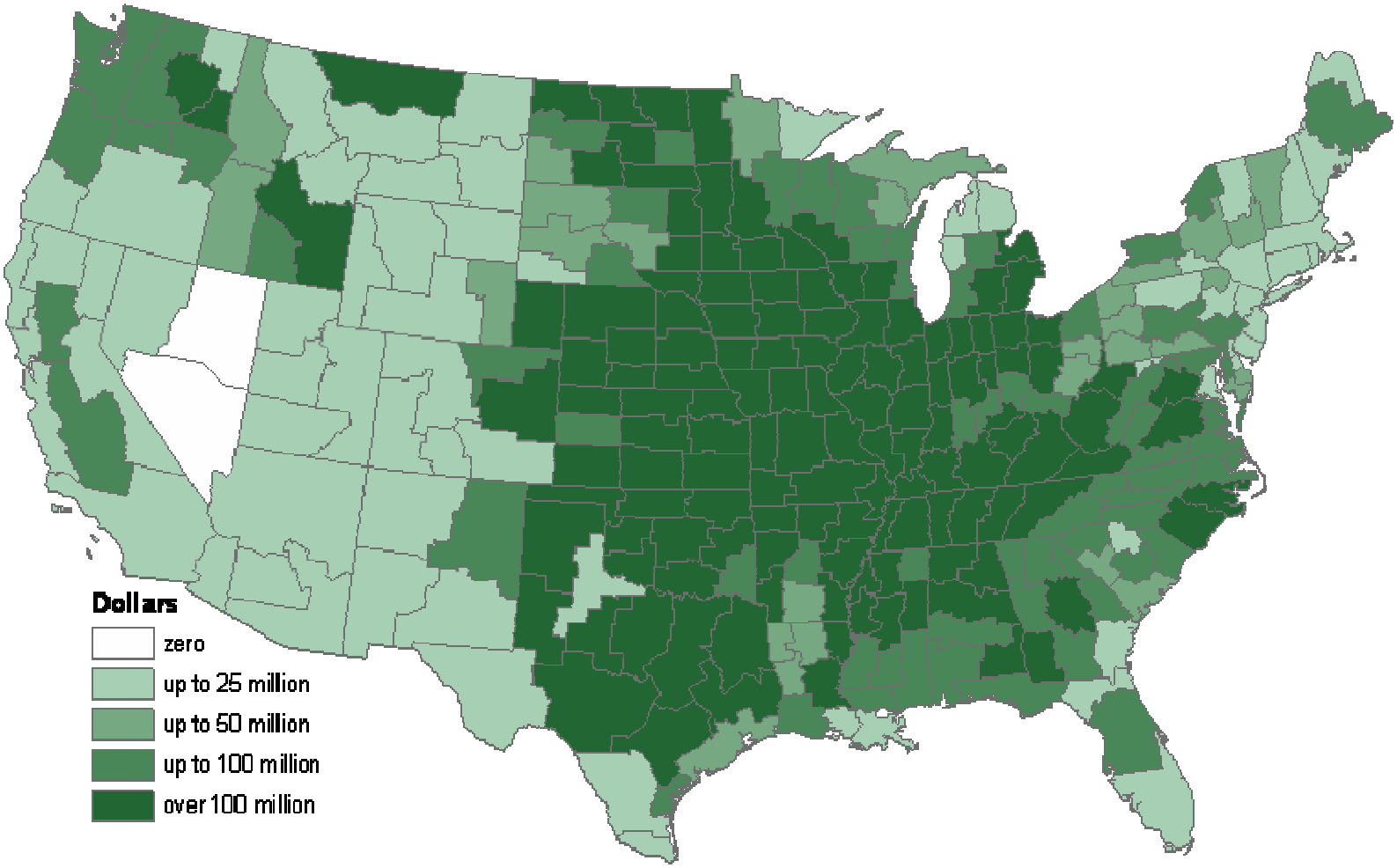


Change in Net Returns -- 2025



Sensitivity on availability of cellulose-to-ethanol path

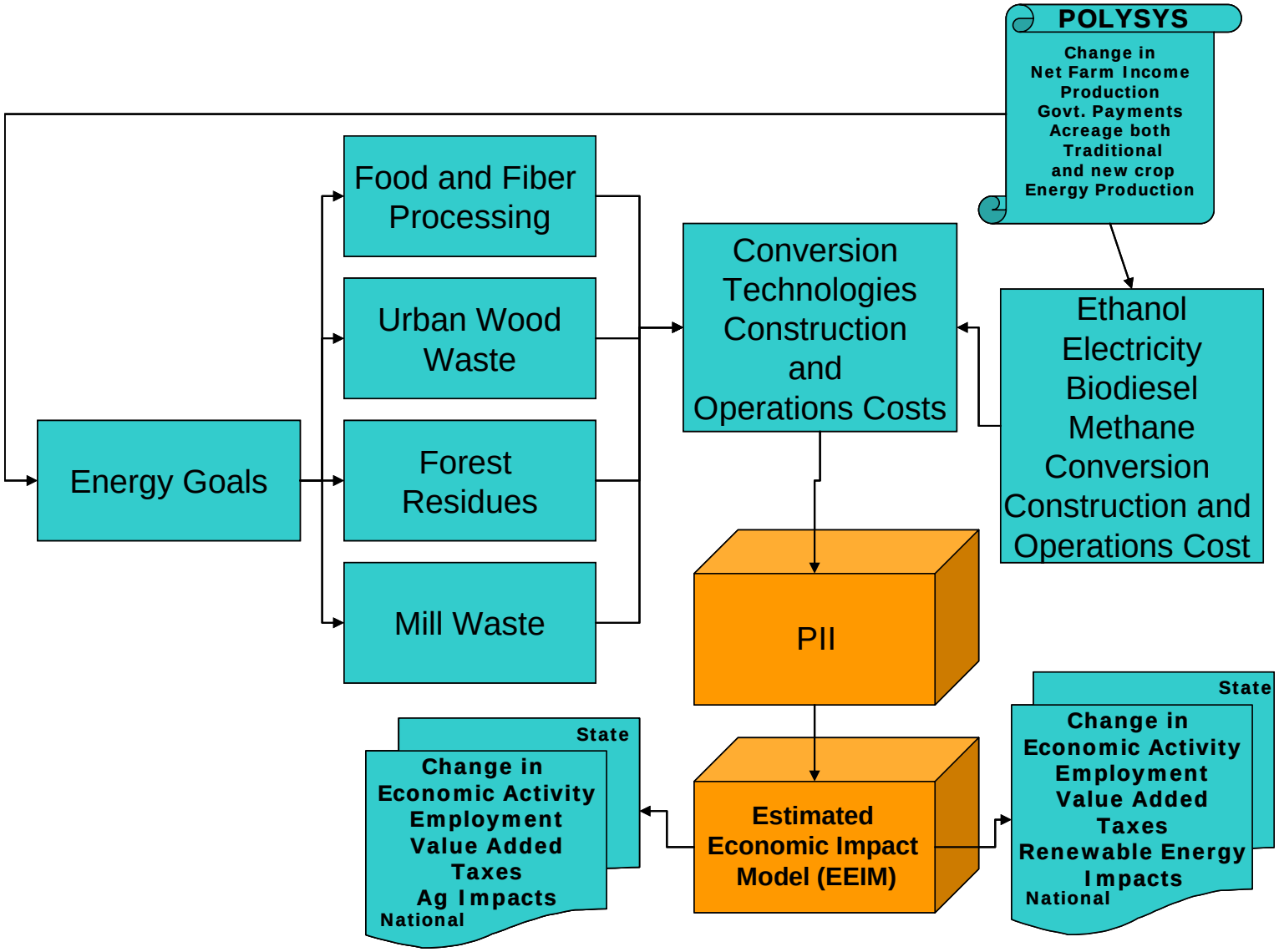
Crop prices in 2015

Crop	Available in 2012	Available in 2015
Corn	1 %	103%
Wheat	-6 %	31 %
Soybeans	2.5 %	45 %
		$/dry ton
Dedicated Energy Crops	46.85	115.00

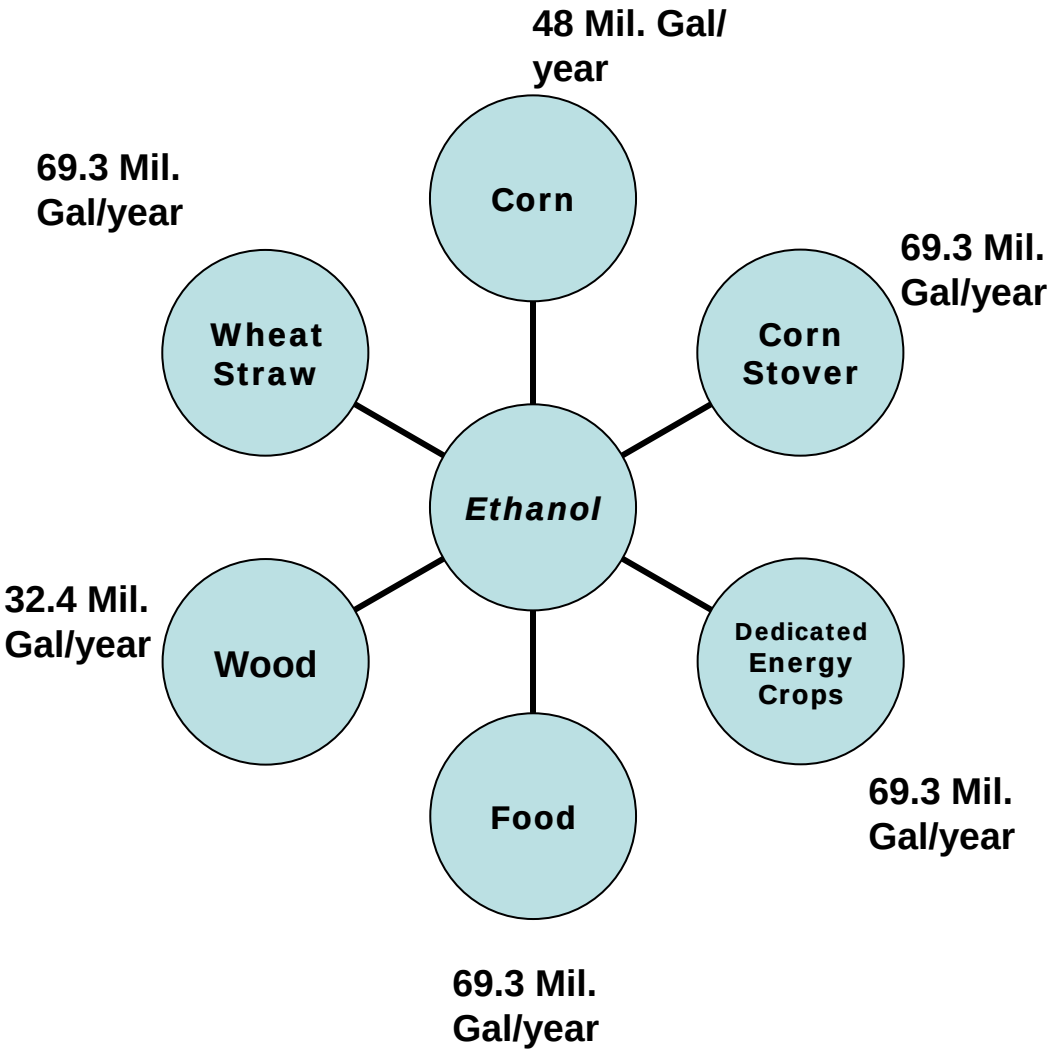
Sensitivity to other key assumptions

- Crop yields
- Conversion yields
- Conversion path contribution to animal feed
- Conversion of pastureland
- World supply response

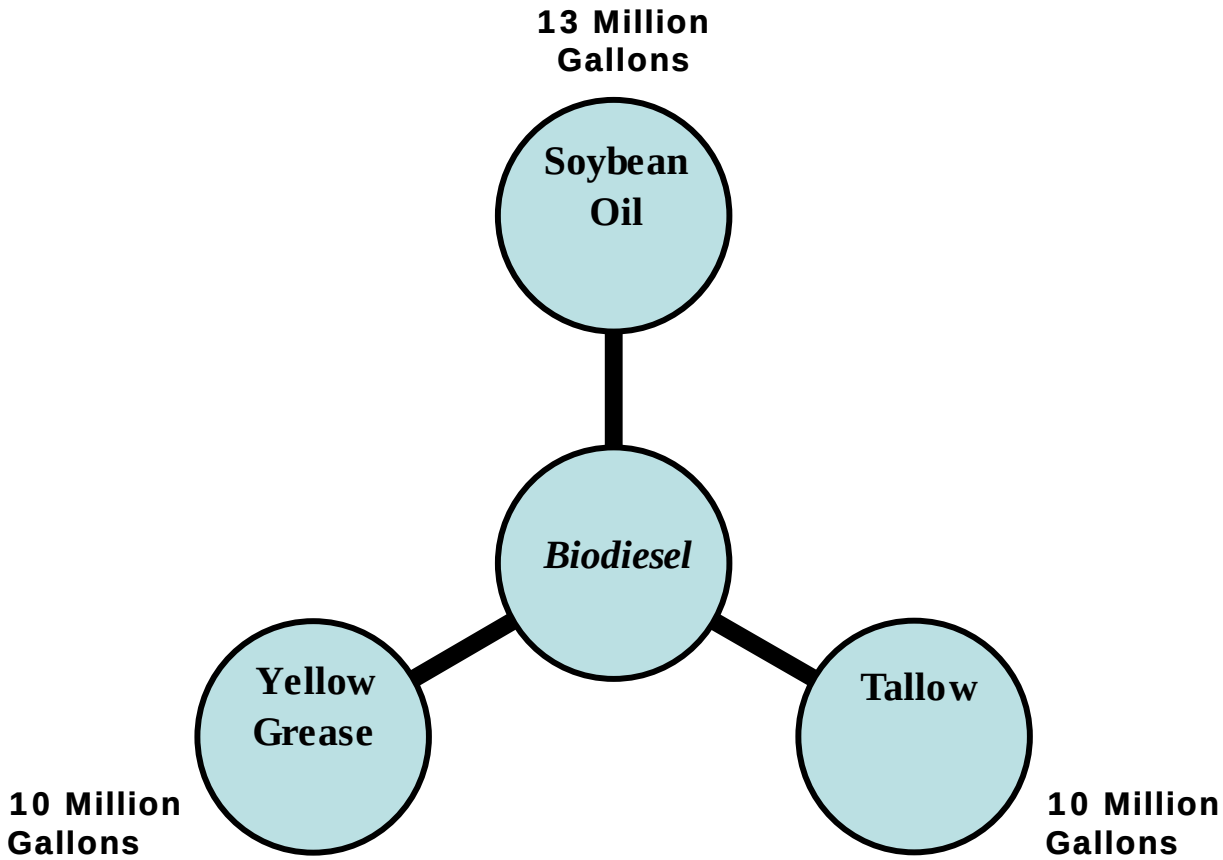
Linking POLYSYS to IMPLAN



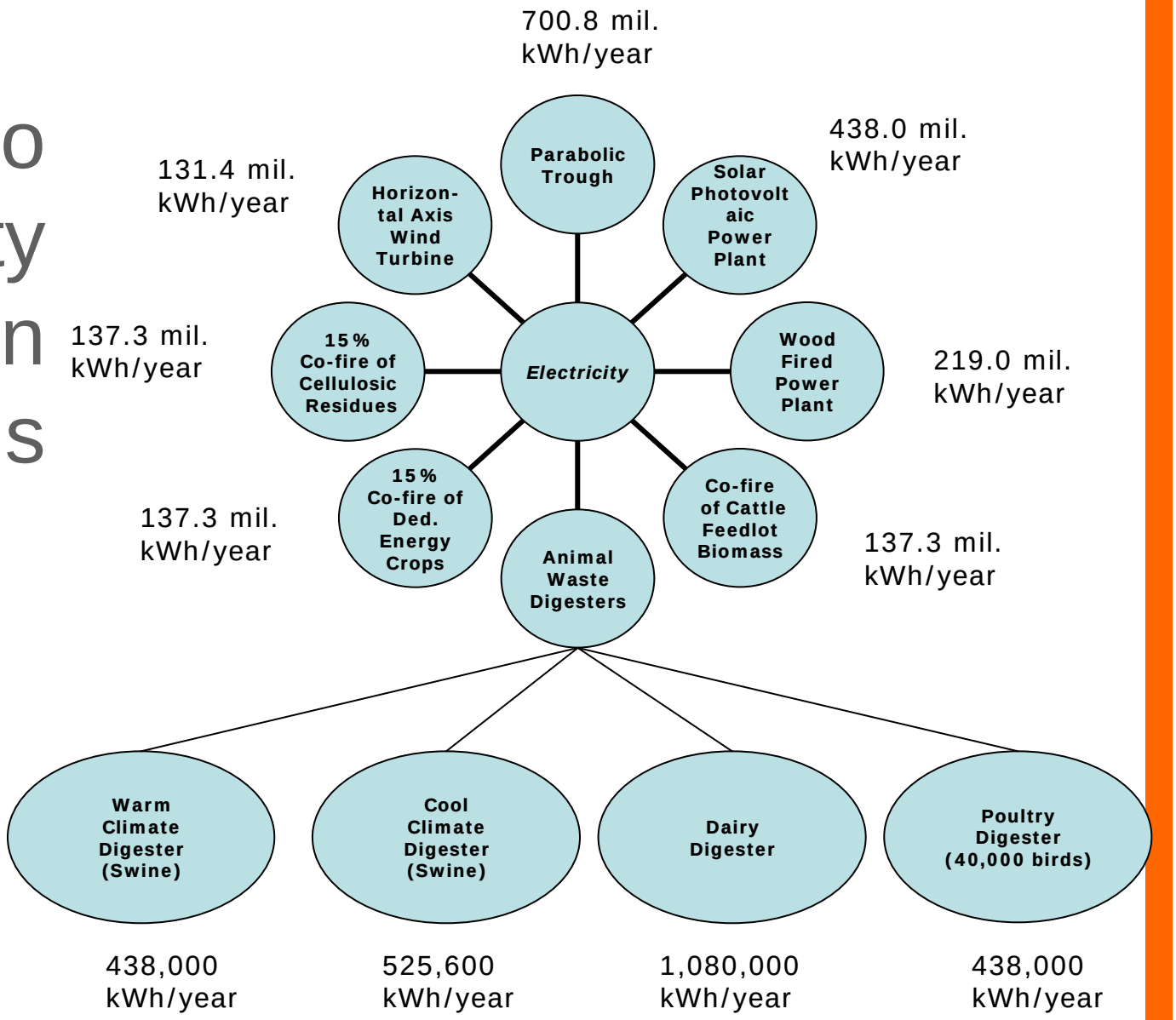
Biomass to Ethanol Conversion Process



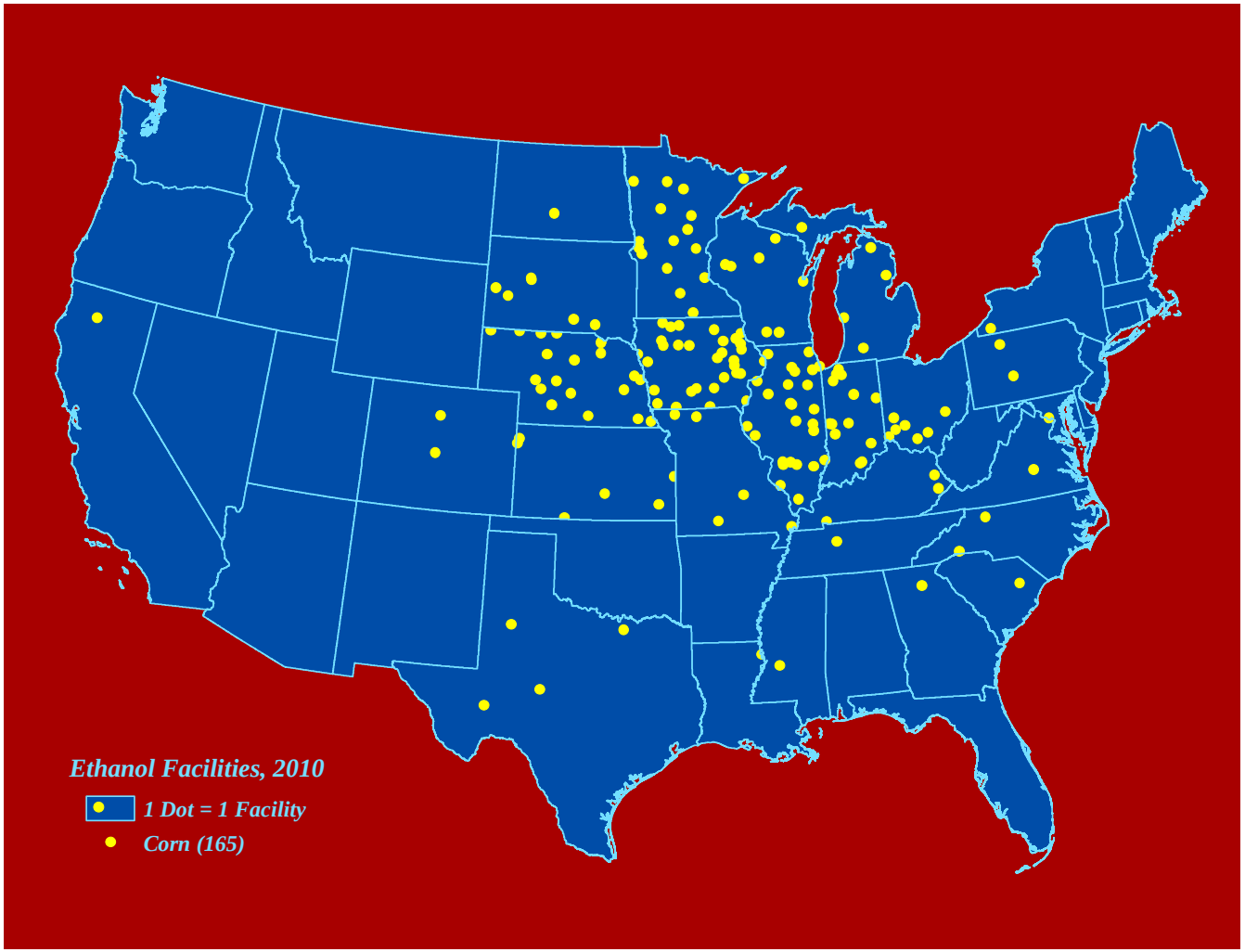
Biomass to Biodiesel Conversion Options



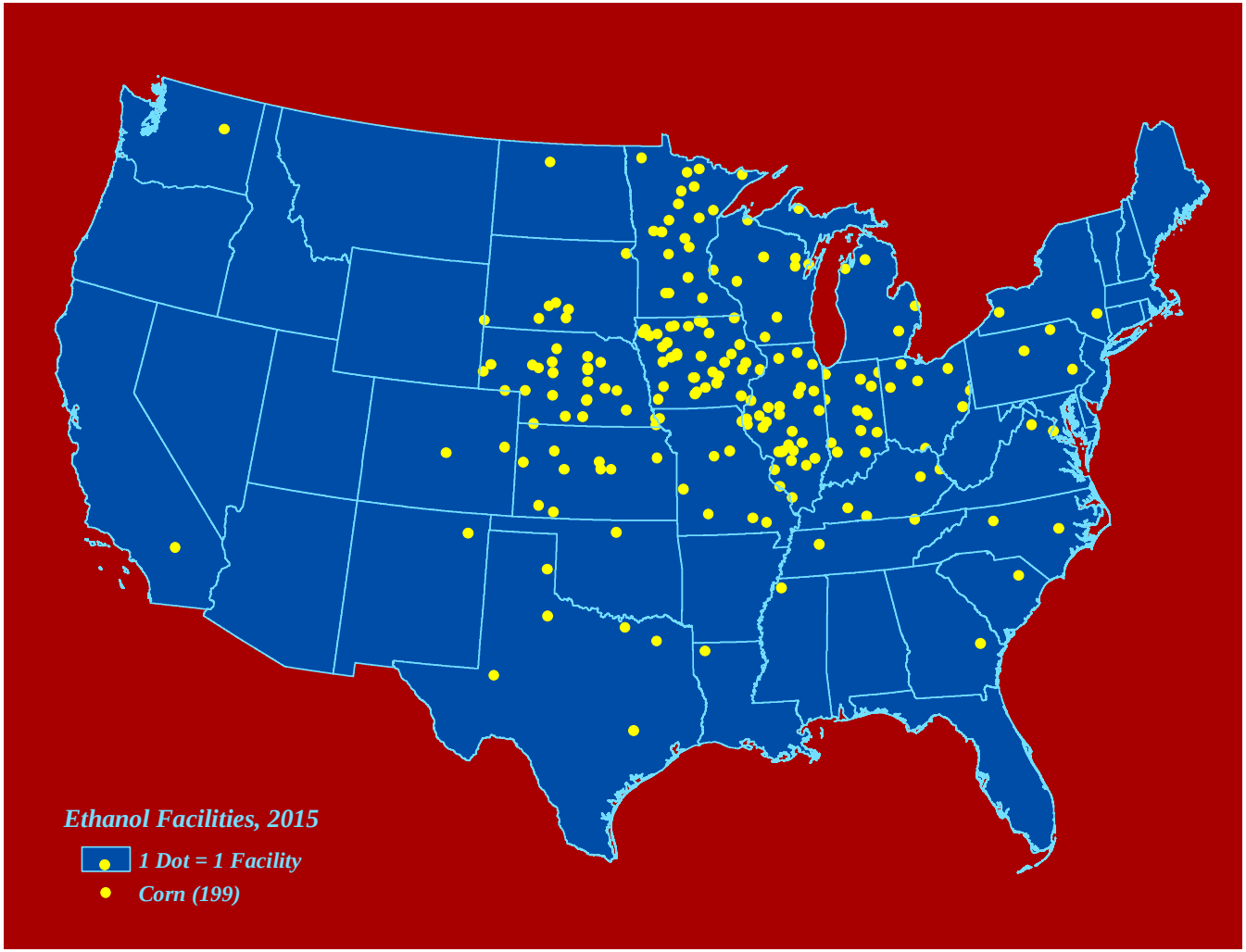
Biomass to Electricity Conversion Options



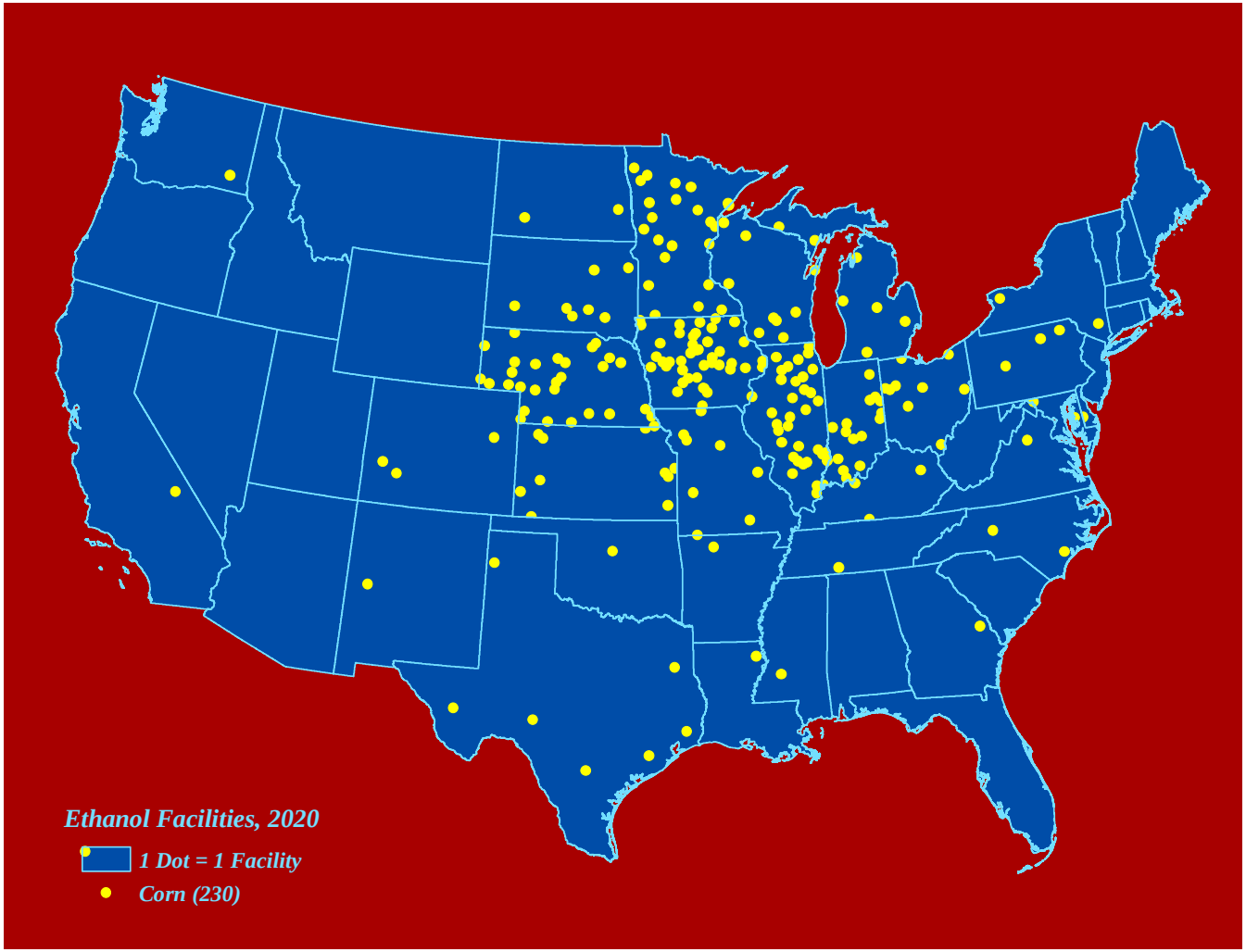
2010 Corn Ethanol Plants



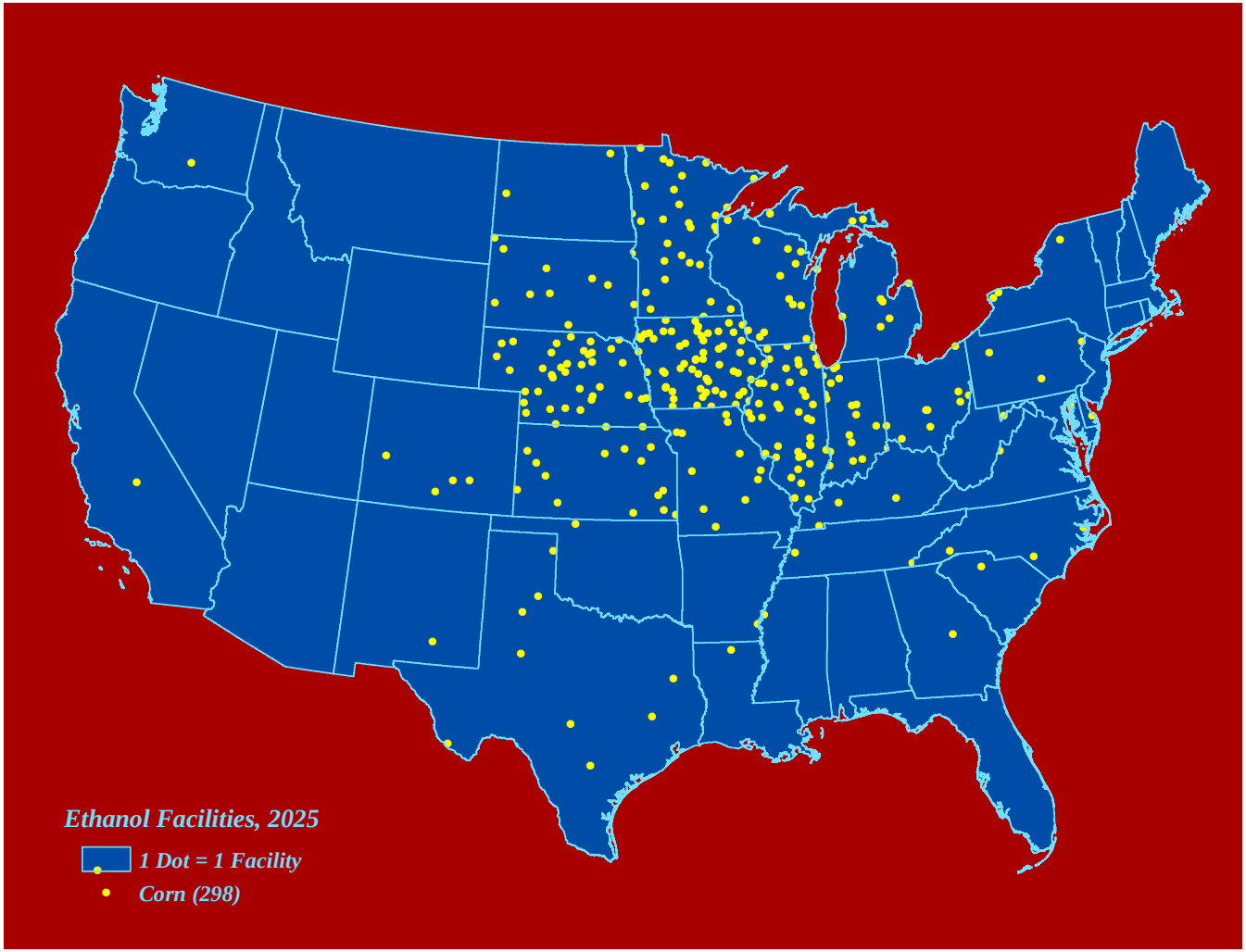
2015 Corn Ethanol Plants



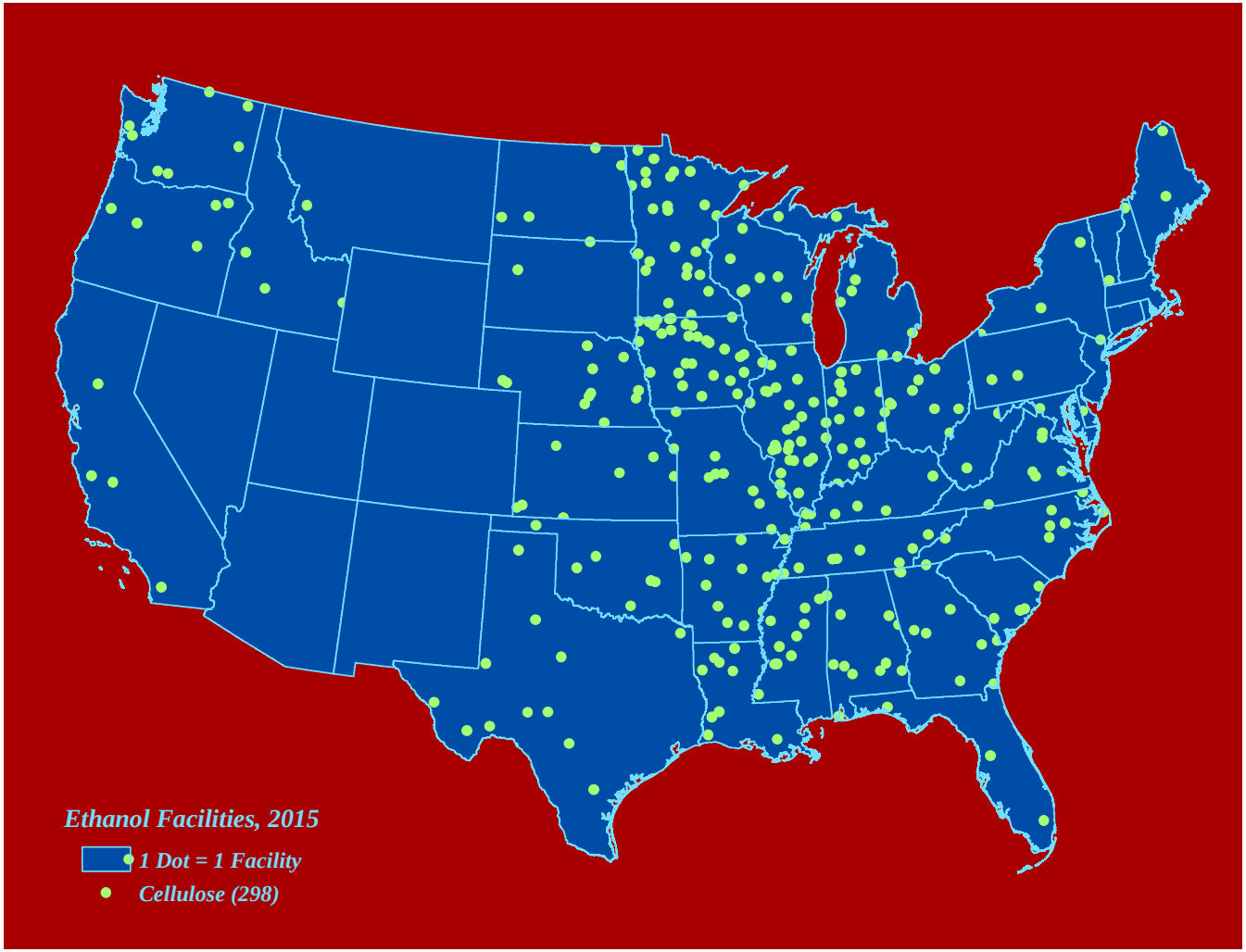
2020 Corn Ethanol Plants



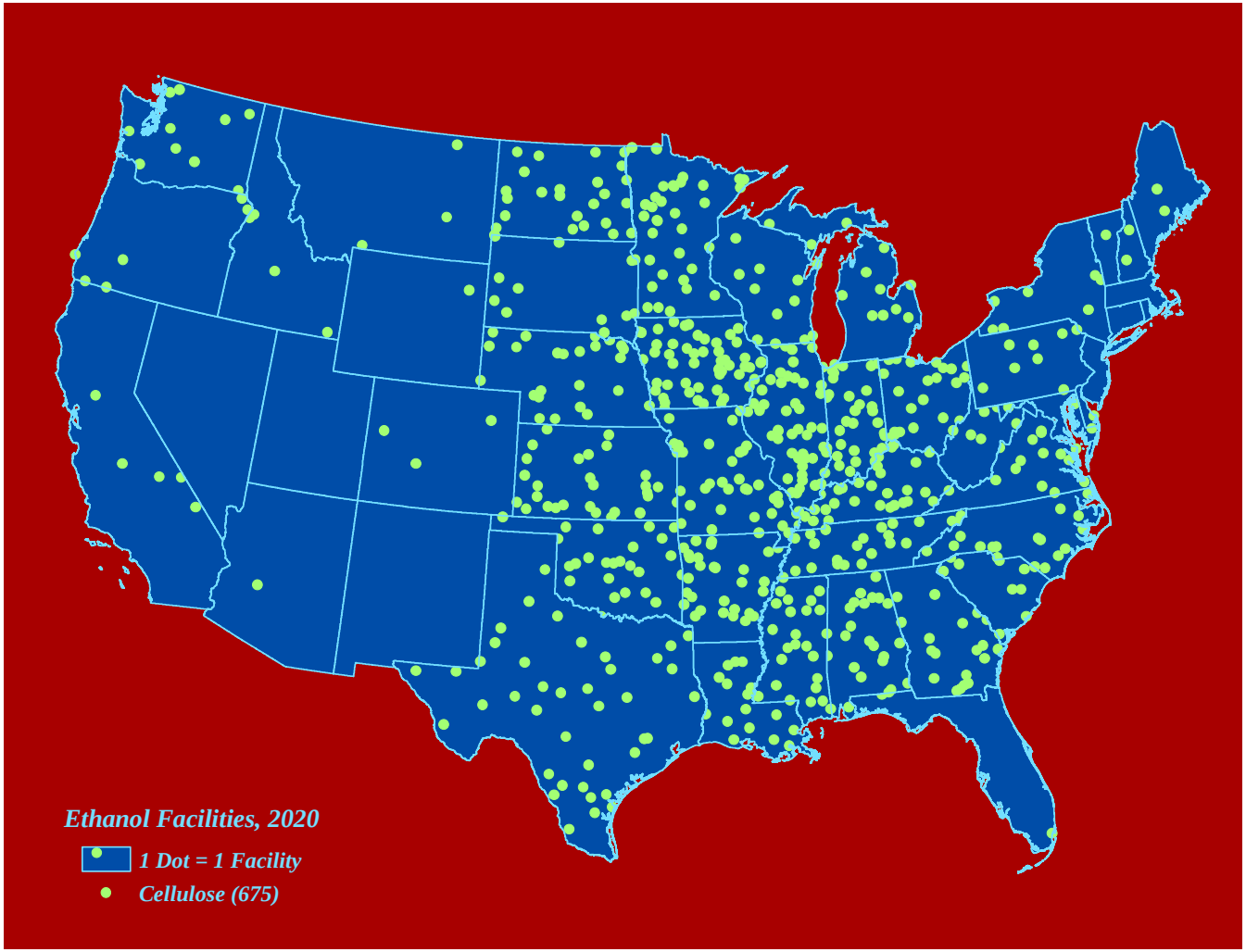
2025 Corn Ethanol Plants



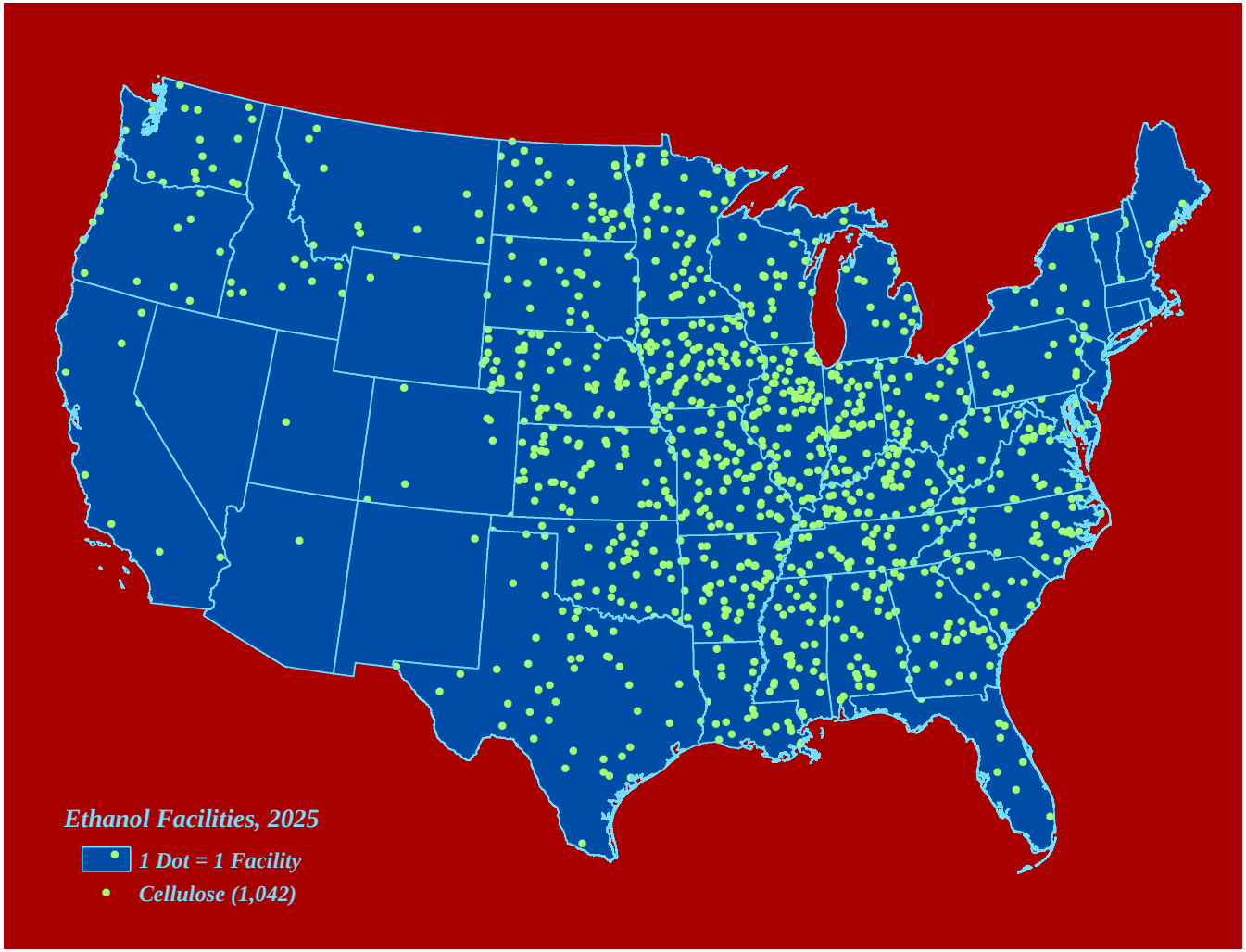
2015 Cellulosic Ethanol Plants



2020 Cellulosic Ethanol Plants



2025 Cellulosic Ethanol Plants

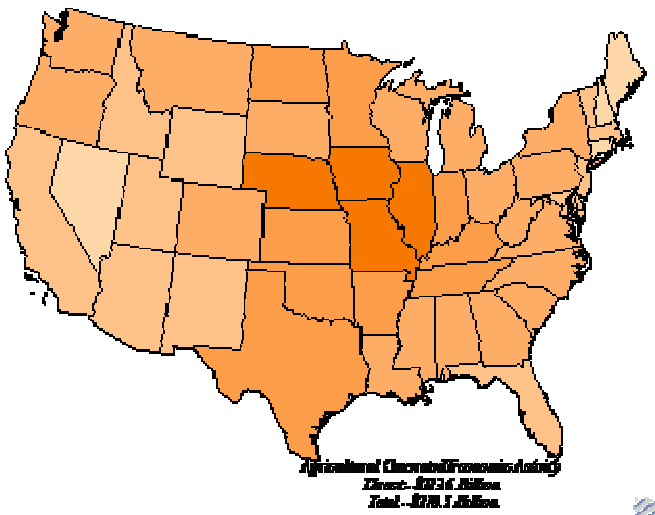


Estimated Annual National Impacts

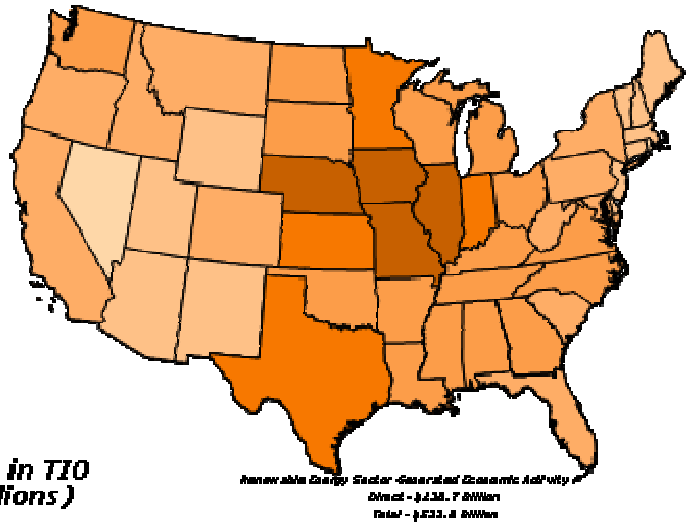
	Change in Industry Output		Impact in Employment	
	Direct Impact	Total Impact	Direct Impact	Total Impact
	million		number of jobs	
2020:				
Agricultural Production Sector	$56,844.9	$86,012.0	536,493.1	828,569.8
Renewable Energy Sector	$93,007.9	$189,137.0	61,892.1	980,656.6
Interstate Commerce	$0.0	$173,503.0	0.0	1,340,315.5
Total	$149,852.8	$448,652.0	598,385.3	3,149,541.9
2025:				
Agricultural Production Sector	$113,664.2	$170,512.2	1,171,760.4	1,749,625.0
Renewable Energy Sector	$138,776.0	$280,854.1	93,390.3	1,460,017.7
Interstate Commerce	$0.0	$252,990.5	0.0	1,955,891.1
Total	$252,440.2	$704,356.8	1,265,150.7	5,165,533.8

Estimated Annual Midwest Regional Impacts
Change in TIO

Agricultural Sector



Renewable Energy Sector

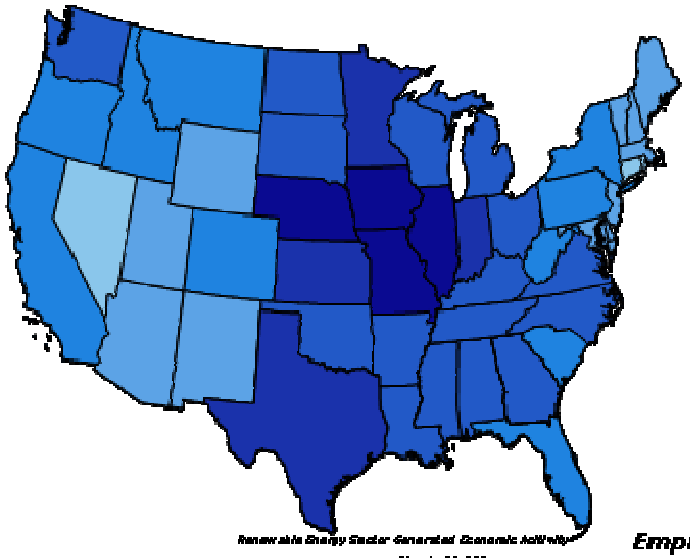


Change in TIO
($ Millions)

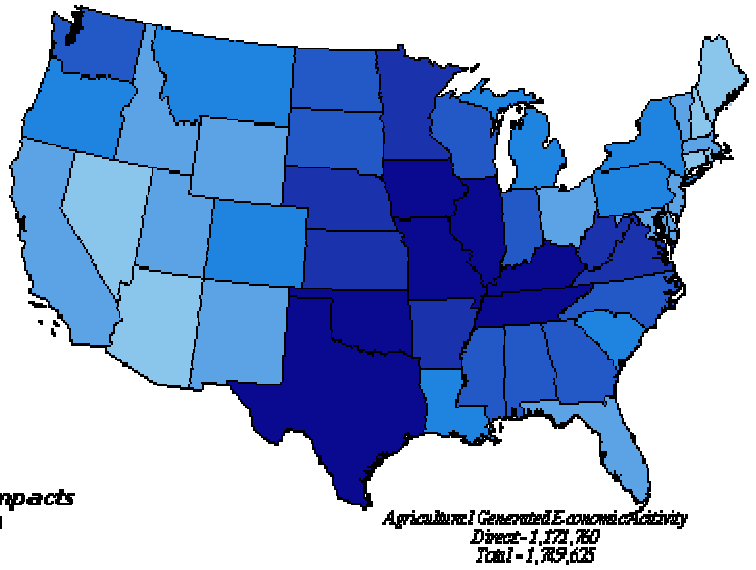
- None
- $1 - $100
- $101 - $1,000
- $1,001 - $5,000
- $5,001 - $10,000
- $10,001 - $15,000
- > $15,000

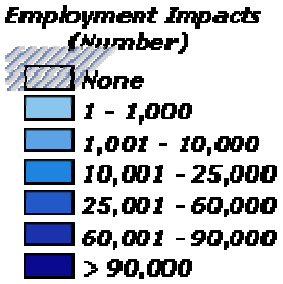
Estimated Annual Midwest Regional Impacts, 2025
Increased Jobs

Agricultural Sector



Renewable Energy Sector





The Challenges

- Cellulose to Ethanol path available by 2012
- Disseminate information for farmers to gear them up to plant 100 millions acres in dedicated energy crops.
- Input availability for energy dedicated crops: seed, chemical labeling, machinery.
- Yield gains
- Logistics for supplying bio-refineries: pre-treatment, transportation, storage.
- Building about 500 -1000 new plants
- Distribution of ethanol
- Ethanol sales infrastructure: E85

Conclusions

- The analysis demonstrated that agriculture and this nation's land base can meet the challenges ahead and projected impacts that might occur if the goals were met.
- The modeling system's livestock sector, forest sector, and demands for pasture land need additional attention.
- A renewable energy demand that is sensitive to the price of oil and policy would be a valuable addition to the model and enhance analysis.
- Plant location and industry expansion needs to be endogenized.
- Incorporate regional dedicated energy feed stocks.
- Address environmental and social concerns

Conclusions (Continued)

- **Investments have to be ahead of the curve:**
  - **Agronomic research**
  - **Pre-treatment and conversion**
  - **Infrastructure of distribution and sales**
- **Government policy needs to be consistent with objectives and speed of adoption**

Project analysis team includes Chad Hellwinckel, Jamey Menard, Roland Roberts, Marie Walsh, and Brad Wilson in addition to Burton English, Daniel G. de la Torre Ugarte, and Kim Jensen

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